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FIELD COMMAND
DEFENSE NUCLEAR AGENCY
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PALOMARES SUMMARY REPORT

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PALOMARES SUMMARY REPORT

15 JANUARY 1975

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DEDICATION

WRIGHT HASKELL LANGHAM, PhD.

1911 - 1972

"Knowledgeable, eloquent and effective" -- a few of the many descriptive phrases that have been applied to Wright Langham, "Mr. Plutonium." We of the Department of Defense remember Dr. Langham of the Los Alamos Scientific Laboratory as a friend and ready advisor. It is particularly fitting that this summary of the Palomares accident, one of many specific instances of Dr. Langham's valuable assistance to the DOD, be dedicated to his memory. We do so in fond appreciation.

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FOREWORD

The accident which occurred over Palomares, Spain on 17 January 1966 and its subsequent recovery operation attracted worldwide interest. This report is designed as a summary which collects the most pertinent data under one cover.

The authors, in assembling the records and recollections of the period, are certainly aware of the problems of assigning relative worth to historical records. The many decisions which had to be made in preparing this summary were based on the answers to two questions. First, "Did the occurrence impact on the Palomares operation or political situation?", and second, "Might a record of the occurrence aid in the prosecution of a similar operation at some time in the future?" If the answers were affirmative, we have attempted to include the information in this summary.

We are indebted to many individuals and organizations for access to their files and memories. Nine years have passed since the operation, so files and memories were sometimes dusty and sometimes destroyed. To each request for information, however, a positive and sincere attempt was made to satisfy our requirement. For this effort, we express our appreciation.

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SECTION 1

THE ACCIDENT

BACKGROUND:

For some years prior to the Palomares accident, the Strategic Air Command (SAC) had been engaged in Operation Chrome Dome, the use of airborne alert aircraft carrying nuclear armament. This concept generally involved mid-air refueling rendezvous at one or more points during a bomber's lengthy mission (Fig. 1-1). As of January 1966, air refueling operations were supported by the Sixteenth Air Force (16AF) with headquarters at Torrejon Air Base near Madrid. Refueling was accomplished by tanker aircraft stationed at Torrejon AB and Moron AB, further to the south (Fig. 1-2).

COLLISION:

On the morning of 17 January 1966, two Operation Chrome Dome B-52Gs, Tea 12 and Tea 16,* rendezvoused with two KC-135As, Troubadour 12 and Troubadour 14,** in the Saddle Rock refueling area at 31,000 feet. At approximately 0922Z (local time in Spain is Zulu + 1 hour) the boom operator in Troubadour 12, while refueling Tea 12, reported to his pilot that he had observed fireballs and what appeared to be a center wing section in a flat spin. This report of disaster was the first of many dealing with the accident and its aftermath. Tea 16 and Troubadour 14 had collided while engaged in the final stages of hookup for refueling. Other aircraft, on other days, and at other places had collided in mid-air. Tea 16, however, was carrying four nuclear weapons. The events summarized in this report were the direct result of that aircraft accident involving nuclear weapons.

The crews of the other B-52 and KC-135 could not immediately determine the source of the falling debris. Troubadour 12 completed the refueling (10-12 minutes) of Tea 12 and then returned to the Palomares area to provide reconnaissance. Attempts to communicate with Troubadour 14 by radio were unsuccessful. Subsequently descending to 4,000 feet, Troubadour 12 sighted unidentifiable burning wreckage and, later, what appeared to be the tail section of a B-52. Other reports reached the Command Post at Moron AB from passing Spanish ships, a British ship, and a civil air liner. The Spanish Guardia Civil (Government Police) began reporting parachute sightings and the status of survivors. When these reports were radioed to Moron AB and passed to Torrejon, the full impact of the accident became apparent.

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* Crews and aircraft assigned to the 51st Bomb Squadron, 68BW, 822 AD, 8AF, SAC and based at Seymour Johnson AFB, North Carolina.

** Aircraft assigned to the 97th AREFS, 97th BW, 42 AD, 2 AF, SAC Crew assigned to 910th AREFS, 340th BW, Bergstrom AFB, Texas, and was on temporary duty at Moron AB.

Figure 1-1 KC-135 Refueling B-52

Figure 1-2 Air Base Locations.

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Eleven men were involved in the collision, four as crew members of the KC-135 and seven on the B-52.

TABLE 1-1

CREW OF THE COLLIDING AIRCRAFT

Crew of KC-135, #61-273, Troubadour 14
17 January 1966

Name and Grade	Service Number	Position
		Pilot
		Co-Pilot
		Boom Operator
		Navigator

Crew of B-52, #58-256, Tea 16
17 January 1966

Name and Grade	Service Number	Position
		Radar-Navigator
		Electronic Warfare Operator
		Staff Pilot
		Navigator
		Co-Pilot
		Gunner
		Instructor Pilot

*Deceased - did not survive the accident

Of the four survivors, all from the B-52 crew, was the only one to come down on land. He was aided by Spanish residents and taken to the Clinic Jacinto Gonzales in Vera,** about 7 kilometers distant. er were picked up by the fishing boat, Dorita.*** was recovered by the fishing boat, Agustin y Rosa.**** Both boats put into Aquilas, a nearby port, where the three survivors were taken to the local hospital and treated. Later that afternoon, they were transferred to San Javier, a Spanish Air Force base about 117 miles up the coast, and from that point were

** In pickup truck of Senor Manuel Gonzales Navarro.

*** Bartolome Roldan Martinez, master

**** Alfonso Orts, master

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evacuated to Torrejon. ' the most seriously injured of the four survivors, was treated at Vera and transferred by civil ambulance to San Javier and evacuated to Torrejon.

As is indicated in Table 1-1, seven of the men were killed as a result of accident. Members of the Spanish Guardia Civil under command of Captain Isidoro Calin took charge at the accident site. Remains were recovered and placed in caskets.* Seven bodies were identified by the afternoon of 18 January with the help of dental and other records. The remains were returned to the United States on 20 January.

INITIAL COMMAND RESPONSE:

The Commander, 16AF, Major General Delmar Wilson, was notified through his command post and passed the report to Major General Donald W. Eisenhart, Hq SAC, at Offutt AFB, Omaha, Nebraska. These notifications set the "Broken Arrow"** response system in motion. The Disaster Control Team from Torrejon was alerted and prepared to travel to the scene. At 1136Z Maj Gen Wilson and three members of his staff*** departed Torrejon by T-39 and surveyed the accident site from the air, landing at San Javier at 1230Z. At 1134Z a C-97 departed Torrejon with 33 members of the Disaster Control Team and three accident investigation personnel and arrived at San Javier at 1240Z. An H-43 from the Torrejon rescue unit and a C-54 carrying jet fuel to support the H-43 were the last aircraft into San Javier on the first day. At 1221Z 17 January, a Disaster Control Team under Maj Gen A. J. Beck, Deputy Chief of Staff, Materiel, SAC, left Omaha arriving at San Javier at 0114Z, 18 January, and at the accident scene at 0630Z.

At 1125Z on the day of the accident, the Joint Nuclear Accident Coordinating Center (JNACC) at Sandia Base (now Kirtland Air Force Base), New Mexico, received word of the accident. JNACC is a joint Department of Defense/Atomic Energy Commission (DOD/AEC) organization charged with coordinating assistance for recovery from nuclear accidents. Its files contain information covering status and capability of DOD and AEC accident response teams throughout the world. In addition it has ready access to the technical capabilities of the atomic community centered in Albuquerque, New Mexico. The Air Force Nuclear Safety Directorate at Kirtland AFB advised JNACC that a team of four of their staff had air transport to Spain and offered space for other response personnel. Representatives of JNACC, Los Alamos Scientific Laboratory**** and Sandia Corporation**** were alerted and departed Albuquerque on the aircraft at 1800Z, 17 January.

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* In the face of tragedy, people-to-people response lightens our load. On the evening of the accident the remains of the victims were brought to the Town Hall of Cuevas del Almanzora, northeast of Palomares. There, among burning candles, services were held by a Spanish priest. Maj Gen Wilson received the remains and they were transported to San Javier and from there, to Torrejon.

** Broken Arrow is the code term used in notifications of nuclear accidents.

*** One of these was an interpreter.

**** Los Alamos Scientific Laboratory and Sandia Corporation are organizations which develop atomic weapons under contract to the USAEC.

As the official contact between USAF and the Government of Spain (GOS), the Joint United States Military Group (JUSMG) was notified of the accident at once. Chief of the JUSMG, Maj Gen Stanley J. Donovan, called on the Spanish Air Minister and on General Augustin Munoz Grandes, Chief of the Spanish General Staff, informing them of the accident, and then proceeded by plane to San Javier.

The United States Embassy in Madrid was notified by the Torrejon Command Post. The Ambassador, Angier Biddle Duke, on being advised, proceeded to the Spanish Foreign Office and reported the available details to the Spanish authorities.

The Spanish-American Agreement in existence then,* defining responsibilities in case of an aircraft accident, provided:

> In case of accident occurring to United States military aircraft or to air carriers which operate under contract to the United States Government, the Spanish and United States authorities will cooperate in the adoption of rescue measures with primary responsibility belonging to the United States authorities. Measures to take charge of and remove the damaged aircraft and its technical equipment are the responsibility of the appropriate United States authorities. Spanish military or police forces shall have primary responsibility for the external security of such damaged aircraft; however, United States military forces, if first on the scene, may assume the responsibility pending the arrival of Spanish military or police forces.

Spanish Guardia Civil personnel were the first government representatives on the scene. They began immediately to secure the area and continued to perform in that and similar capacities for the duration of the recovery operation.

By the evening of the day of the accident, 17 January, 49 U.S. personnel had arrived at Palomares. That number would increase in the days that followed to more than 650 at the accident site. The tone of the recovery operation was set when President Johnson, while breakfasting in his bedroom at the White House, was advised of the accident and that the situation involved four thermonuclear weapons. He phoned the Secretary of Defense, and after checking on the danger of a nuclear detonation, instructed that we should "do everything possible to find them."

PALOMARES:

The village of Palomares lies near the southeastern coast of Spain (Fig. 1-2) in the province of Almeria. It is so small that it is not included on many maps, nor was it included in the census. At the time of the accident, its population was estimated to be approximately 2,000 persons. By American standards Palomares would be considered a poor village, although

*Procedural Agreement No. 14 to the 26 September 1953 Agreements, Operation of Military Aircraft," 12 November 1954

probably somewhat richer than most in Almeria, the forty-ninth of Spain's fifty provinces in per-capita income. The area was once rich in metals, with evidence of mining activity dating from as early as 3500 B.C. It was later settled and its metals extracted to support the far-reaching commerce of the Phoenicians. Metals, however, no longer contribute to the area's economy. The abandoned mine shafts are the only remains of this industry. The presence of these diggings in the area was to play a part in the search for a missing bomb.

Palomares is also sufficiently arid that its only industry, agriculture, must depend on deep well irrigation. Relying on this irrigation, the village had been able to enjoy a modicum of prosperity. Farming the irrigated land produced alfalfa, beans, cotton and two wheat and two tomato crops in 1965. The tomatoes accounted for the village's principal economic input in that year, about $250,000.

Electricity, provided by a local generator, came to Palomares in 1958 and with it, radios and a few television sets. These modern media which were to carry the Palomares story to the world would also involve the people of that barriada (hamlet) in the diplomatic and propaganda maneuverings of the nuclear powers.

The people of Palomares are farmers and farm laborers, but the waters off the Palomares coast were the harvest grounds of many fishermen from nearby ports and villages: Villaricos, Aguilas, and Garrucha. These people, after playing the major part in the rescue of the surviving airmen, were to be excluded from parts of their fishing grounds by the extensive underwater salvage operation which was to follow. (Section III).

One can imagine the response of individuals on the ground to the collision 30,000 feet above them. The refueling operations were not new to the residents of Palomares. Many "hook-ups" had been witnessed on other occasions. This day, however, was to be different. Some saw the collision; others looked up only when they heard the explosion. What all saw was the burning aircraft wreckage falling about their village and farm plots. The B-52 had broken apart at high altitude. The KC-135, however, remaining fairly intact as it plummeted to earth, apparently exploded just before ground contact (1600 ft) and again on contact. Engines, wing sections, gear and other smaller pieces fell about the countryside, in back yards and open fields. The debris pattern on land was spread over several square miles. Father Serraro, a circuit priest from Cuevas del Almanzora who tended to Palomares parishioners, suggested that "the hand of God" had protected the village. Aside from being frightened, no person or animal was injured nor was any structure damaged - other than broken windows and the like.

THE BOMBS:

As the first Americans arrived in Palomares, the priorities of the task before them were fairly obvious. First, there was concern for people, crew members of the aircraft and residents of the village. After Maj Gen Wilson had seen to the condition of the surviving airmen in Aguilas and the remains of the deceased in Cuevas, he was assured by local authorities at Palomares that no injuries had been sustained by the populace. Some members

of the response force had performed initial radiation surveys, predominantly around the areas of major wreckage. These surveys indicated that there had been no nuclear explosion. Somewhere, in the gathering darkness, four nuclear weapons had to be located. There were many stories to be told by the Spaniards who had seen parachutes with projectiles attached, but there were few of the Americans who could understand the language. Just before dark, Sgt Ramond Howe, who had been conducting radiation monitoring of some of the wreckage, learned of a possible weapon from a member of the Guardia Civil. That report led the team to its first find about 900 feet from the beach and southeast of the village (Fig. 1-3). The weapon was only slightly damaged on impact. It apparently had fallen against a soft, high bank and rolled to the bank's base (Fig. 1-4). Radiation checks were negative. The team decided to leave render-safe* procedures until morning as it was now too dark to accomplish the task. Air Force guards were posted at the weapon. The weapons were given numbers in the order in which they were found. The team spirit rose at the relative ease of the Number 1 find and at its good condition.

Darkness and the rugged terrain in another search area a mile west of the village made it necessary to postpone this search until morning.

At first light, the small force gathered at the B-52 tail section which was to be used as a command post (Fig. 1-5). All available personnel were pressed into the search effort. By 0930 hours**, the second weapon was located. Number 2 turned out to be the bomb that had evaded location the previous evening. Unlike Number 1, however, Number 2 had been substantially damaged upon impact. Part of the weapon's high explosive had detonated but as designed, no nuclear detonation had taken place.***

Portions of the weapon were in a crater of about 20-foot diameter and 6 feet in depth. Other parts of the weapon assembly were found as far away as 100 yards. Weapon render-safe procedures were not required here. The primary concern with Number 2 was the plutonium contamination that must have been released by the high explosive detonation. Radiation detection equipment indicated the presence of significant alpha contamination in the area.

At approximately 1030 hours, one hour after Number 2 had been located, Number 3 was discovered within the limits of the village of Palomares. It's high explosive had also detonated but again there had been no nuclear detonation.*** Parts of the weapon were strewn to distances of 500 yards. Plutonium contamination was also present at this site.

---

* Render-safe refers to the procedures employed to insure that a weapon's firing system is disarmed.

** Times are local unless indicated otherwise.

*** The term used to describe this required design feature is called one-point safety. It is defined as a probability no greater than one in one million that if a nuclear weapon undergoes detonation on any one point at anyplace in the high explosive system the weapon will not produce a nuclear yield of energy in excess of 4-pounds TNT equivalent.

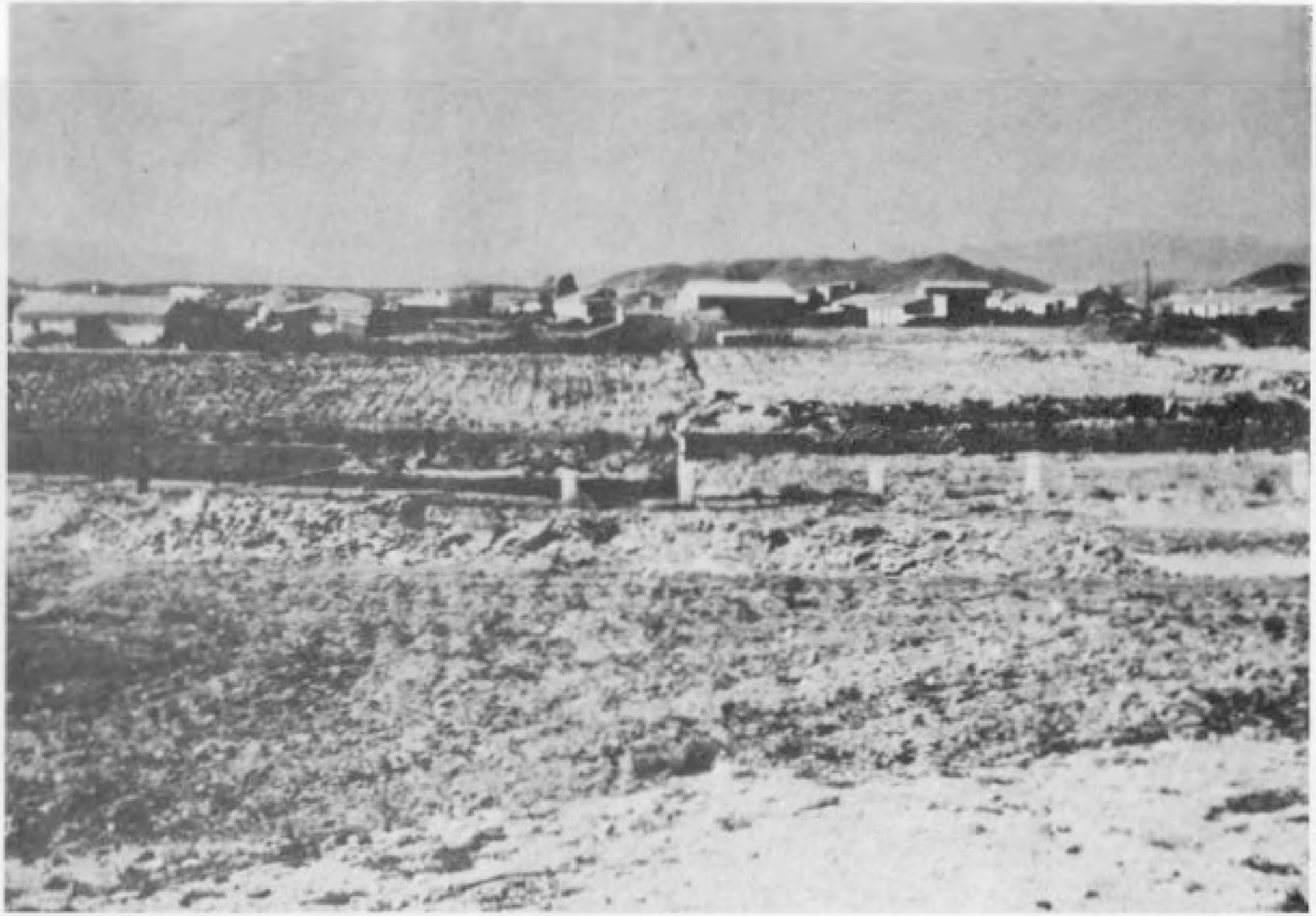

Figure 1-3 Embankment SE of Palomares

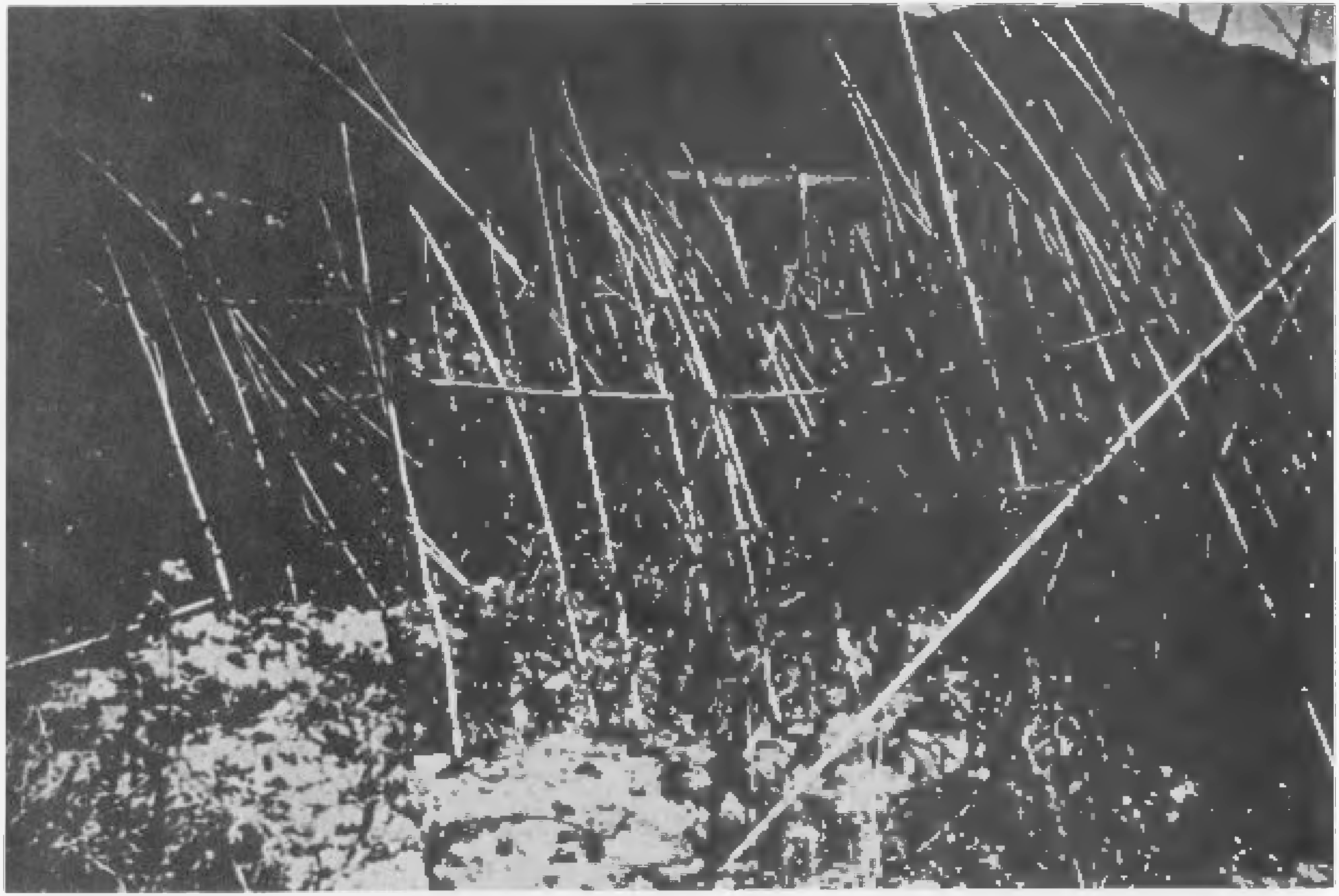

Figure 1-4 Weapon at Base of Embankment

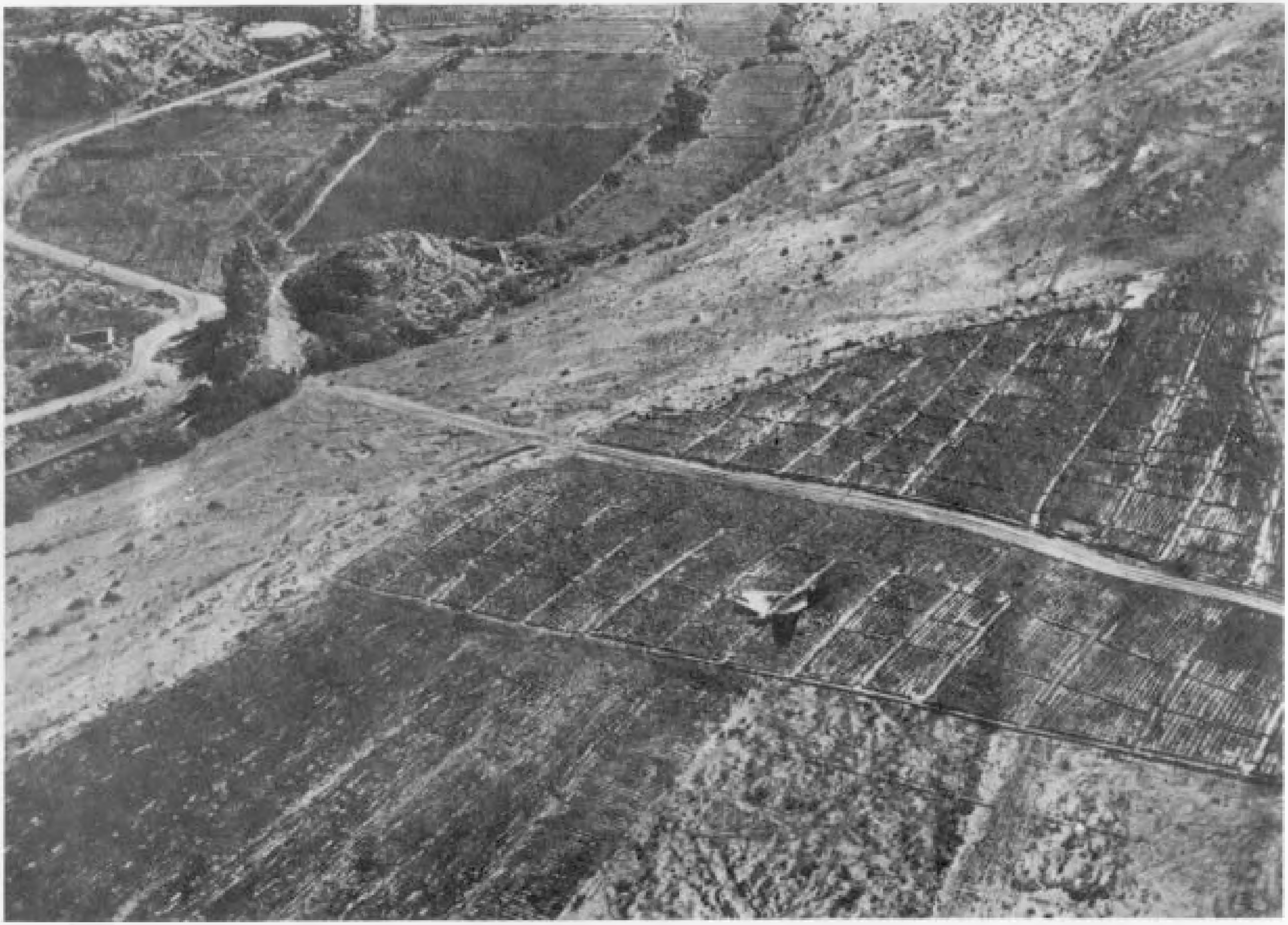

Figure I-5 B-52 Tail Section

Weapon Number 1 was lifted by helicopter and loaded on a truck. Debris from Numbers 2 and 3 were collected by Explosive Ordnance Disposal (EOD) personnel and boxed for shipment. Heavy debris could not be lifted by helicopter at sites 2 and 3 because downdrafts caused by the craft's rotors would have caused spread of contamination. The packaged debris was trucked from Palomares to San Javier and flown to Torrejon on 20 January. There it was repacked, minimizing the opening of the temporary containers. Before the shipment was airlifted to Amarillo, Texas, it was used at Torrejon as a calibration source for an aircraft mounted radiation detection system (Section 2). The shipment left Spain on 30 January 1966.

The location and recovery of weapon Number 4 is covered in Section 3. It suffices here to say that the weapon had fallen offshore with its main parachute deployed. It was not recovered from the sea until 7 April 1966. The weapon was essentially intact and not contaminated. Render-safe procedures were conducted by 16AF personnel on board the recovery vessel.

SAFETY CONSIDERATIONS:

Small as it is, the probability of a nuclear yield in an accident makes nuclear weapon safety the first concern at all levels of military command, including that of the Commander-in-Chief. In response to our national policy with regard to nuclear safety, weapons designers employ a number of means to insure against an unplanned nuclear detonation. In general, weapons are designed so that a positive event or sequence of events peculiar to its planned mode of delivery or attack must occur before a weapon will produce a significant nuclear yield. It is reassuring that the safety engineering that was employed in the weapons was successful in preventing a nuclear explosion at Palomares and it is important to note that there has never been an accidental nuclear explosion involving United States weapons.

SECTION 2

LAND OPERATIONS

Recovery operations subsequent to the accident covered 81 days and involved activities both on land and at sea. The types of operations and methods involved in the two environments are sufficiently different that it seems reasonable to treat land and sea operations in separate parts of this narrative. Where significant interaction between the two operations occurred, it will be noted. Otherwise the reader should remember that the operations proceeded concurrently. (Refer to Section 3 for Sea Operations.)

ESTABLISHING CAMP WILSON:

Though the remaining daylight time was limited when Maj Gen Wilson and the Disaster Control Team arrived at the scene, it was recognized that this would be a major recovery operation. Even before it was known that one weapon would be difficult to locate and recover, the task of cleaning up the debris was such that several weeks could be required. It remained the responsibility of the 16AF Commander to actually coordinate all recovery efforts, to judge what was needed to do specific tasks, and to request the necessary assistance in both personnel and material support.

Not realizing that a pattern was being set that would be followed for some 80 days, the evening of 17 January 1966 was spent in planning the work for the next day. From what had been seen of the wreckage, it was decided to bring personnel in from the two Spanish bases, Moron and Torrejon. Movement started at 0100Z on 18 January from Moron, followed by a second convoy at 0310Z. A total of 126 U.S. personnel were transported in six buses. Accompanying the convoy was an ambulance, and a van and truck carrying bedding, food, water, and radios. From Torrejon the first of the two convoys started at 0137Z, the second at 0202Z, with 175 persons in six buses, and an accompanying ambulance. It soon became apparent that some personnel did not have the necessary gear to participate in such activity, but it was almost impossible for those at Torrejon and Moron to realize the conditions at the accident site. It was a 12- to 14-hour drive to the southern coast, so that the first of the buses arrived about 1300Z, and the last about 1700Z. The first night of their stay meant sleeping any place possible: in buses, on the ground, and a fortunate few in hotels. Meals consisted of in-flight rations which had accompanied the personnel or which were flown in through San Javier. The area used for the camp, and where it remained until the following Friday, was at the impact site of the B-52 tail section (Fig. 1-5).

Tent City:

Tents and related equipment were requisitioned late January from Gray Eagle* stocks at Wheelus Air Base, Tripoli. With this equipment a temporary camp had been established at the dry river bed site by Wednesday, 19 January (Fig. 2-1). By Friday, earthmoving

* The concept of prepositioning forward operating base assets in support of tactical air deployments.

Figure 2-1   Temporary Camp Site

equipment had leveled a more suitable area on higher, firmer ground 3 1/2 miles east of Garrucha. This site lessened a dust problem and eliminated the potential of flash flooding. The 75-tent camp with its helicopter landing area and motor pool served until 3 April as "forward base" for the specialized task of cleaning up the Spanish countryside. From 3 April to 11 April, the camp closed and moved nearer to Garrucha.

Population:

From the original Disaster Control Team of 36 that went to the scene from Torrejon, the numbers grew rapidly, reaching a peak by 31 January (Table 2-1). Two-thirds of these personnel were involved in either hunting for the weapon or in cleaning up the debris, while the remaining were air police, communications, medical, claims, and other support personnel. Of these, 598 were Air Force, 64 Army, and 19 Navy, with those listed as Air Force including 4 technical representatives. As of 31 January, Maj Gen Wilson listed the functional alignment of U.S. people as listed in Table 2-1.

TABLE 2-1

PERSONNEL AND FUNCTIONS

200	ground search
200	detection, decontamination, harvesting
23	accident investigation board
23	civil engineering
30	camp support
6	legal claims
5	medical
58	communications
2	helicopter operations
41	air police
7	information and public relations
19	Navy ordnance disposal
4	technical representatives
7	Army engineers
36	transportation
20	command and staff

All except some of the officers were housed in the camp itself. Those few were quartered in two hotels close to the accident scene, one of these having opened specifically to house these personnel.

Population at the camp varied, but from the 31 January high there was a gradual reduction until the camp was closed on 11 April. The initial high was reduced gradually as the diposal of aircraft debris was accomplished, although about two hundred were still engaged in search for the missing weapon and about the same number in decontamination activities.

The first major reduction occurred on 9 and 10 February when about 50 of the cleanup personnel and the 40-man ordnance disposal team left. Gradual reductions then took place as the ground search was finally considered as complete as possible, and Maj Gen Wilson recommended to U.S. Air Force on 4 March that it be terminated. A slight upswing occurred from 11 to 17 March during the period of filling of 4,810 barrels with contaminated soil and crops preparatory to shipment to the United States for disposal.

Other personnel at the camp site, although not housed there, were the approximately 126 Guardia Civil and the 39 Spanish personnel (maximum number hired) who worked along with the Americans in the cleanup of the aircraft debris, as well as some who were hired in the camp for work in the kitchen. Table 2-2 shows the camp population.

TABLE 2-2

PERSONNEL AT CAMP WILSON AND SAN JAVIER
17 January - 11 April 1966
(as of Monday, weekly)

	Camp Wilson Americans	Spanish (less Guardia Civil)	San Javier Americans	Total
Jan 17	49	0	1	50
24	583	0	50	633
31	665	37	73	775
Feb 7	666	25	53	744
14	632	36	51	719
21	661	36	47	744
28	618	33	50	701
Mar 7	522	33	42	597
14	471	32	31	535
21	330		31	361
28	144		28	172
Apr 4	34		12	56

The primary mission of the medical support organization was to provide emergency medical treatment, to supervise field sanitation, and to furnish assistance in bioenvironmental work in connection with potential radiation exposure. While no cases of hazardous radiation exposure were treated, all other cases requiring treatment beyond the emergency type were air evacuated to either Torrejon or Moron, with the majority going to Torrejon. Support was furnished to the Navy when required and included evacuation of several cases to Torrejon.

One tent was assigned as a dispensary type medical facility and manned by personnel from both bases (Fig. 2-2). By 21 January there were two medical officers, both of whom were specialists in aviation medicine, and six airmen.

The majority of the medical problems involved upper respiratory infections since the weather was quite cool and windy much of the time. There were sprains and blisters suffered by those who were walking in the fields and hills in the search parties. However, only 33 cases were listed as requiring air evacuation from 19 January through 1 March.

Water Supplies:

During the first three days, acceptably pure drinking water had to be trucked 81 miles from Cartegena. The next week a source at Lorca (48 miles away) was used. Following this, Camp Wilson was supplied at the beach site by the Navy. Proper medical precautions prevented any gastrointestinal disorders, although the Navy had reported cases of gastroenteritis from an unclean storage tank aboard a cruiser. Storage capacity of drinking water was only approximately 2500 gallons. Local sources provided water for showers and decontamination (Fig. 2-3; 2-4).

Sanitation:

Although bathing facilities were of an improvised nature until 31 January, regular monitoring revealed no contamination. On 31 January, a detachment of Company A, 308th Supply and Service Battalion, arrived to establish laundry-bath facilities (Fig. 2-5). Daily personnel decontamination procedures required bathing and clean clothes for each person possibly exposed to alpha radiation.

As an aid to personal hygiene, a local barber was permitted to establish a "shop" at the camp (Fig. 2-6).

Heating:

Daytime temperatures reached as high as 80-90 degrees. Wind conditions and sea dampness along with 40-45 degree night temperatures made tent heaters necessary to avoid a too-high rate of respiratory infections. Accordingly, kerosene (Aladdin) heaters were in use by 3 February. Briefings on proper use and strict fire patrol procedures precluded any problems in their use.

Figure 2-2   Tent Dispensary

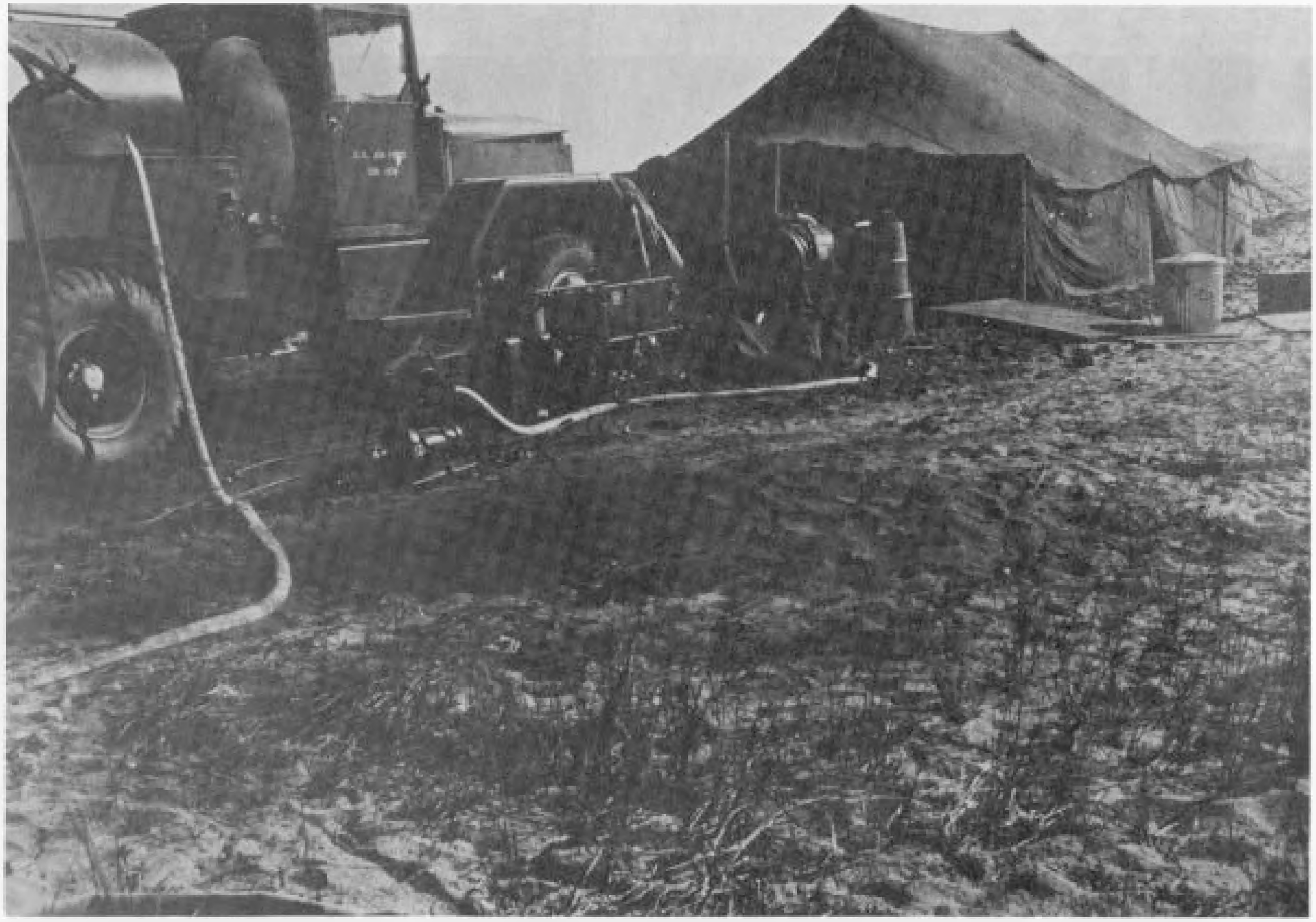

Figure 2-3 Decontamination Tent

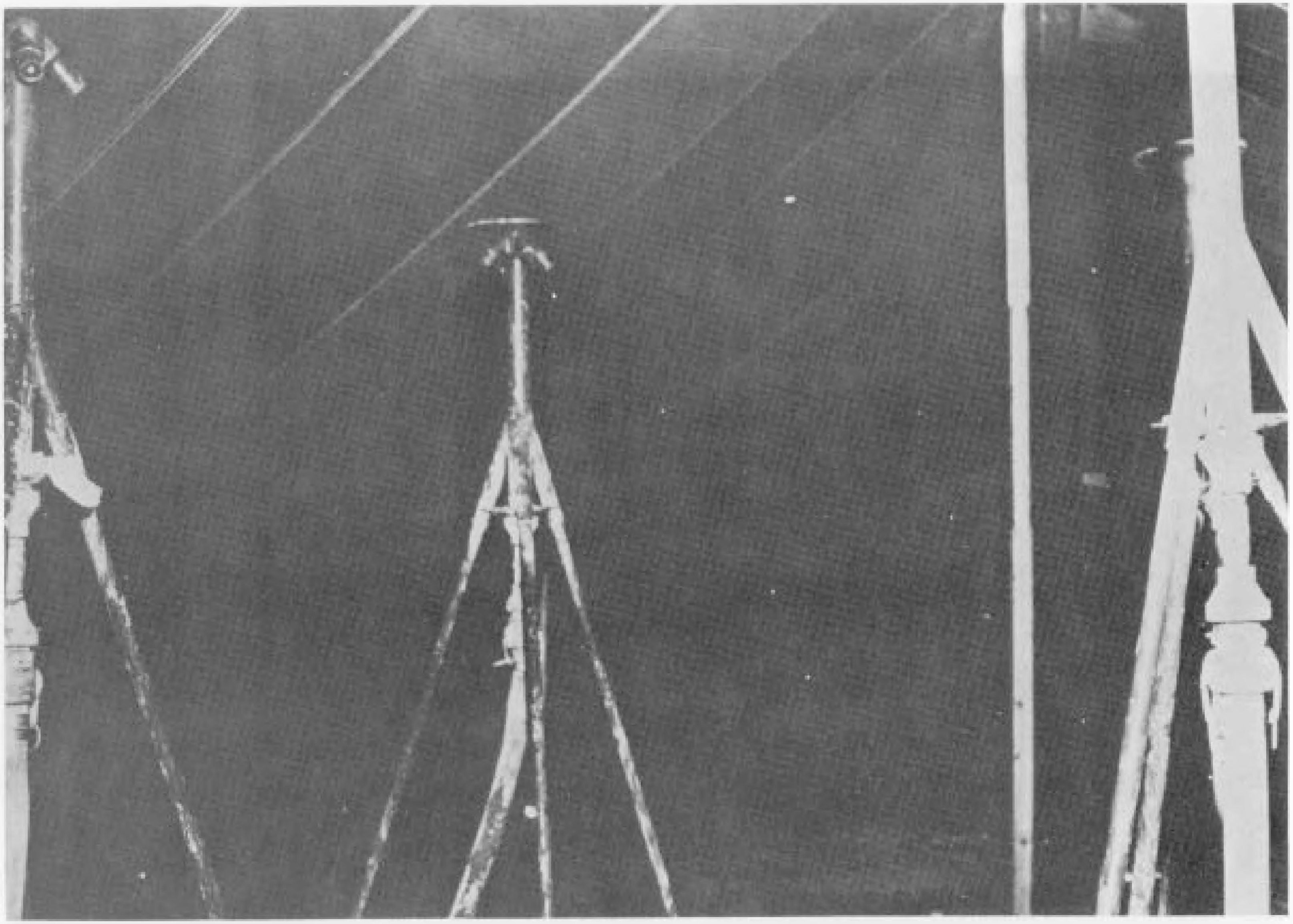

Figure 2-4 Decontamination Showers

Figure 2-5 Camp Wilson Laundry Operations

Figure 2-6 Local Barber

Messing:

After Gray Eagle equipment became available, hot meals were served (Fig. 2-7; 2-8). Daily courier flights from Torrejon to San Javier, with transfer to helicopters, permitted milk and fresh bread to be flown in along with the necessary rations. Tomatoes were harvested during the crop disposal program, and those free of contamination were purchased and used for troop feeding.

Some Guardia Civil and Spanish laborers, who worked with the Americans at the site, were also furnished meals.

Discipline and Morale:

There were no serious disciplinary problems. Stringent shore leave and off-limits policies were in effect. Movies, sports such as volley ball, soft drinks and beer were available in camp. A USO show was presented on 20 February.

Certain gimmicks, such as specially devised emblems, search unit nicknames, and banners, helped smooth out the ups and downs. Clearly spelled out rotation and R&R (rest and recuperation) policies helped balance out the frustration of the long search for the missing weapon. In general, the camp was efficient and well run with local resolution of all problems that occurred.

LOGISTICS AND SUPPLY:

Logistics for Operation Recovery was a major function in its total support. The accident site had none of the essentials for support. Every item of supply had to be transported in, most of it over a very poor road network. Maj Gen Wilson decided early in the operation that his force should be supported so as to create as little impact on local residents as was possible under the circumstances. Thus, a field camp situation was necessary as there was no local housing available.

Gray Eagle:

Gray Eagle supplies, airlifted from Wheelus AB, provided immediate basic camp necessities and eased the Operation Recovery effort considerably. Normal Gray Eagle packaging for deployment did not allow access to specific items. For instance, when Operation Recovery required machetes, 60 cases might have to be opened to satisfy the requirement. In all, 306,853 pounds of Gray Eagle equipment were provided to Camp Wilson. Although it had been airlifted to Spain, it was returned to Wheelus AB via ship from Cadiz.

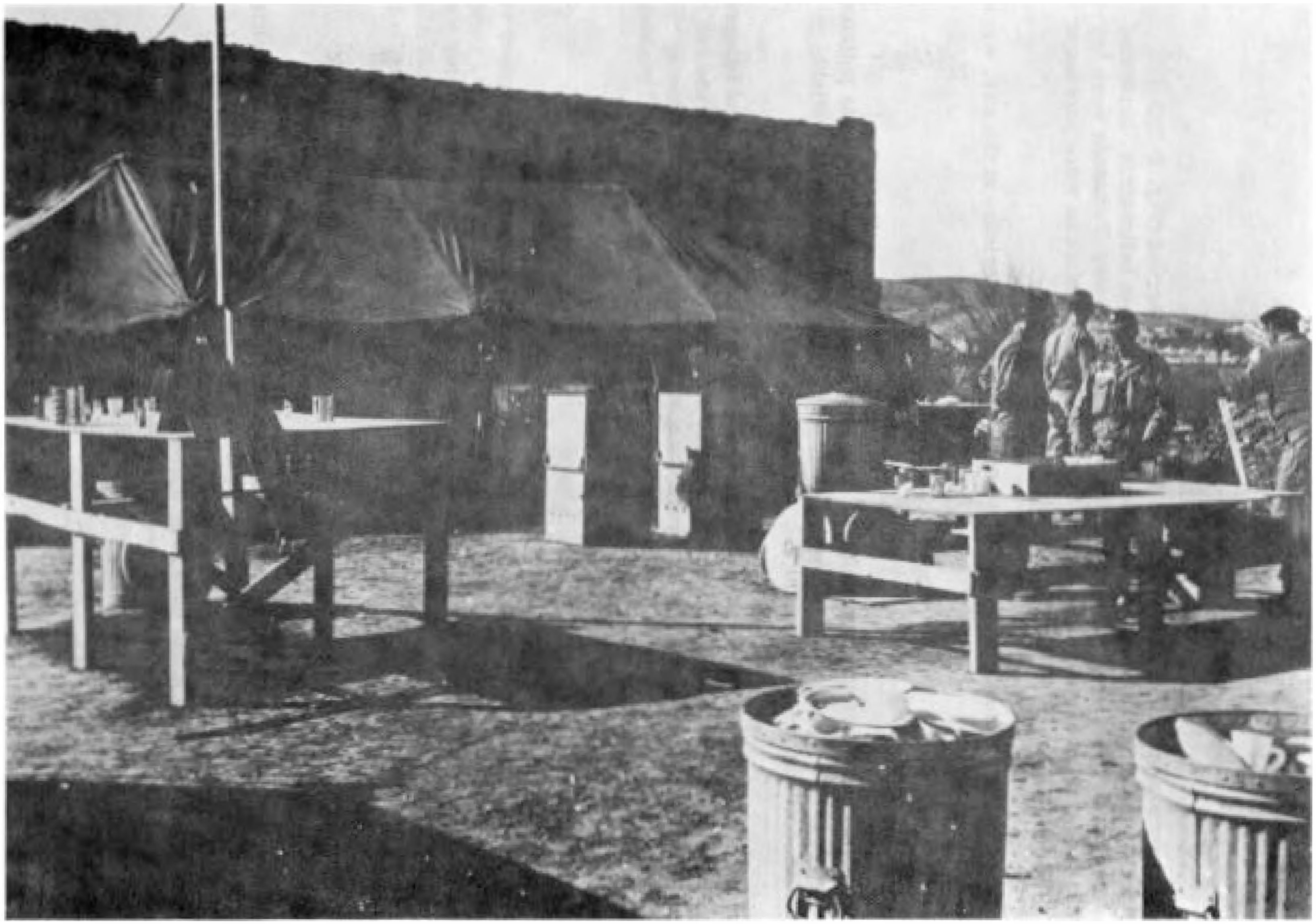

Figure 2-7 Camp Wilson Field Kitchen

Figure 2-8 Camp Wilson Dining Area

Surface Transportation:

Camp Wilson had no airstrip. Most of its logistic support was flown into the area via San Javier and then trucked to the site. During one period, 148 vehicles were involved in Operation Recovery, 21 by the unit at San Javier and 127 at Camp Wilson. Types of vehicles used were varied: supply and personnel vehicle, tank trucks and pumpers, road grading equipment, limb shredders, wreckers, forklifts and tractors are examples. These vehicles were augmented by commercial truck and rail as required.

Sixteenth Air Force vehicle assets were exhausted by the effort, and requests went to other commands for support. A long-lived major problem was vehicle maintenance. The problem was aggravated by parts supply problems and apparently because vehicles in poor condition had been supplied by agencies involved. At one point in the operation, the 16AF sent a TDY (temporary duty) team to the United States to expedite the flow of supply parts.

Table 2-3 provides an indication of the vehicle requirements of the operation as of 15 February. By 13 April, all surface transportation except for a station wagon used by the Claims Office were returned to home stations. The vehicles that were not owned by 16AF were repaired before their return.

Radiation Detection:

In the field of radiation detection instrumentation, portable equipment for alpha detection has historically been troublesome for open terrain surveys. To a large extent the problems with this instrumentation are inherent to their design and to the characteristics of alpha particle radiation. The plutonium alpha particle has a very short range in air (3-4 cm), and cannot penetrate a blade of grass or a thin film of ground moisture. Thus, the alpha detector must be positioned extremely close to the surface to be monitored, so close that even in the hands of experienced personnel, there is danger that the surface irregularities (grass, rock, etc.) will penetrate the extremely thin window of the detector's wand (Fig. 2-9; 2-10).

Because the PAC-1S was the only alpha detector available, it should not have been surprising that logistical problems would be encountered in Operation Recovery. The instruments suffered an unusually high failure rate. Maj Gen Wilson stated that the U.S. Air Force was unprepared to provide adequate detection and monitoring for its personnel when an aircraft accident occurred involving plutonium weapons in a remote area of a foreign country.

To provide an adequate number of detectors in commission at any one time, a large number of instruments had to be available at the site. Sixteenth Air Force asked USAFE and SAC for all the instruments that could be spared. To fulfill this request, PAC-1S detectors were brought in from eight European locations, fourteen U.S. sites, and one from Africa.

Several lessons were learned from the use of the PAC-1S instrument during this operation. These were:

TABLE 2-3

VEHICLES AT CAMP WILSON, 15 FEBRUARY

Type	Description	Quantity
Bus	29 Passenger	10
Carrier	3/4-ton, 4 x 4, M-37	2
Caterpiller	D-6	1
Compressor	Air	3
Forklift	6,000 pound	1
Grader	Road	3
Jeep	1/4-ton, 4 x 4	11
Mixer	Concrete	2
Pumper	530 B	3
Shredder	Tree	2
Trailer	Water	3
Trailer	Refueling	2
Trailer	10-ton, semi	3
Tractor-Trailer	5-ton, semi	1
Tractor	Farm	3
Truck	6-passenger, pick-up	9
Truck	3-passenger, pick-up	3
Truck	1 1/2-ton, stake & platform	2
Truck	2 1/2-ton, IH, Cargo	7
Truck	2 1/2-ton, Refueler	6
Truck	Water Distributor	16
Truck	Ambulance	2
Truck	Dump	13
Truck	2 1/2-ton, 6 x 6	5
Wagon	Station	5
Wrecker	--	3

1. Acceptable radiation levels had to be established at varying values according to the texture of the terrain before adequate monitoring could become effective.

2. SAC, USAF and AFLC* identified a requirement to develop a more reliable alpha monitoring instrument for field use in monitoring radiation from plutonium 239.

3. Due to limited training and the problems of alpha particle detection using the PAC-1S, the more experienced, maturer airmen augmentees to the Disaster Control team were more effective than lower-grade airmen.

*Air Force Logistics Command

Figure 2-9   Monitoring in Rough Terrain

Figure 2-10   Alpha Monitoring with PAC-1S

4. In conjunction with the above lesson, all monitors for this type of accident had to be given extensive training before they could conduct a first-class monitoring program. Familiarization training on what the instrument looked like and how it operated was not sufficient.

5. Under no circumstances, should PAC-1S instruments be deployed to the field again without pertinent directives and a repair capability.

The experience at Palomares was to be a major forcing function on the requirement for a new plutonium detection system. One was developed and was available in prototype when the B-52 bomber nuclear weapon accident occurred at Thule, Greenland, in January 1968. Rather than detecting the alpha radiation, this instrument was designed to detect the low energy, but relatively more penetrating gammas and X-rays present in weapon plutonium. A normal alpha detector would have been useless in terrain survey at Thule. Drifting snow would have masked any chance at alpha detection.

Airlift Support:

Sixteenth Air Force requested and received aircraft assistance from several sources. The Army provided HU-1 helicopters (16AF provided JP-4 fuel) to conduct search operations. Airlift consisted of tankers from Torrejon and Moron, theater aircraft, and unrestricted use of eight Military Airlift Command (MAC) C-124's and C-130's until they were released on 7 March by 16AF. In addition, MAC used three civilian Boeing 707's to deliver Operation Recovery equipment on four occasions.

One aircraft accident occurred during the recovery operation. A MAC C-124 crashed at Granada, Spain, 12 February. The entire aircrew was killed and the logistic supplies, two buses and lights for Camp Wilson, were lost.

Communications:

Communications, like logistics, was a "build it up" process for Operation Recovery. Although the Compania Telefonica National de Espana pointed with pride that, "At a minimum, every village in Spain had at least one telephone," there were none at Palomares. Thus, when Maj Gen Wilson set up shop at Palomares, the nearest telephone was located at Vera, about 10 miles distant - 40 minutes to travel and a general wait of an hour for a circuit. Priority was given for establishment of SSB (single side band) capability. Units had been brought by the team arriving at Palomares on the evening of the accident. By 1859Z that night, communications were established with Torrejon. At this stage, secure communications were not available. Air Rescue cover aircraft also provided early relay service to San Javier.

The Spanish government, recognizing that San Javier would be heavily utilized for the operation, offered its air defense microwave system with terminal at that base. A telephone connection to this system was established at San Javier on 18 January.

The next increment of communications capability came on line at Camp Wilson on 22 January, providing a secure teletype service to Torrejon among other capabilities. This service was provided by U.S. personnel and mobile equipment of the Second Mobile Communications Group of Toul Rosieres AB, France. This circuit was relayed through Croughton, England. Several attempts were made by a second unit from the French base to establish direct communications from Palomares to Torrejon, but the quality of the service did not equal that of the Croughton link, and attempts were abandoned on 3 February.

Maj Gen Wilson desired that at least two methods of communication be available in case one system should fail. A necessary link in this program was the lack of wire service from Palomares to Vera. The Spanish telephone/microwave system could provide service from Vera to Torrejon. At 1230Z, 22 January, a request for a landline to fill the gap and for an in-camp telephone system was initiated with U.S. Army support units in Europe. By 2200Z, on 23 January, the Palomares-Vera line had been laid, and by the next moring the in-camp net had been installed. The reaction can only be described as meritorious.

With the arrival of Task Force 65 in the waters off Palomares, ship-to-shore communications had to be implemented. Single side band (SSB) and VHF links were established and operated satisfactorily throughout the operation.

Helicopter operations in the area also required communications support. Air Force helicopters were UHF equipped, while those of the Army used VHF. Both services were established with satisfactory results.

One last communications service should be mentioned. The search operations covered considerable territory. Portable radios were used by the several teams which were spread over the area. For this purpose, as well as for all radio operations in the area, coordination was required with the Spanish government for allocation of frequencies. Authorization was received in all cases on a priority basis.

FIELD OPERATIONS:

Table 2-1 provides an indication of the many activities which were underway at Camp Wilson. Three topics were uppermost in all minds. These were the search for Weapon #4, decontamination, and the completion of the accident investigation. Each of these activities was supported by a fourth, the cleanup of aircraft and weapon debris.

Aircraft Accident Investigation Board:

The Board gathered eye witness statements, reconstructed the path of flight of the aircraft and the probable contact area, and collected all available facts concerning the cause of the accident. The first formal board meeting was held on 20 January in a building in the village of Palomares. The Board was assisted and advised by a team from SAC, Deputy Inspector General for Safety, Oklahoma City Air Materiel Area, the Boeing Company, 8AF, and 2AF. Interviews were conducted in Palomares, Vera, Aquilas, Cuevas, and as far away as Murcia, Spain. An interpreter was required since witnesses were Spanish fishermen, farmers, and

shepards. The structures and aerodynamics group of the Board required a crane to turn wreckage so that fire pattern areas, structural failure points, etc., could be detected. On 28 January, the Board returned to Torrejon to continue formal proceedings, interview surviving crew members, and complete the investigation. The aircraft accident investigation was completed and the report forwarded by 8 February.

Search For Weapon #4:

The basic problem was to analyze ballistic trajectory, define the search area, and locate the fourth weapon. The Board theorized that the B-52 and all weapons experienced deceleration as a result of the breakup of the aircraft. The tail cover assembly from Weapon #4 was found northeast of the B-52 tail area and in line with Weapons #2 and #3. After the initial B-52/KC-135 collision, a rupture of one longeron occurred just aft of the B-52 trailing edge. The forward fuselage pitched downward with ultimate loads snapping the left wing off. The weapons were then tossed out. Weapon #2 was found with a major piece of the bomb rack still attached, and after theorizing, it was determined that high G-loading had occurred, causing the relatively massive weapons to separate at approximately 4 to 5 seconds after the initial longeron failure. Weapons #1 and #3 apparently did not tumble, and they initiated chute deployment in the first few seconds after release. It was reasonably certain that Weapon #2 was tumbling when it fell. Weapon #1 was found with its chute intact and it did not incur an HE* explosion. Weapon #2 experienced an HE explosion. Case fragments and approximately 10 pounds of HE were found within 300 feet of its crater. Weapon #3 also had an HE explosion on impact, scattering approximately 80 pounds of HE and plastic within 100 feet of its crater. One fragment was found approximately 1500 feet from the crater.

The main effort of the camp was now directed toward locating the missing weapon and sensitive documents and equipment. The search started from beyond the last known wreckage and worked toward the sea. Searching was conducted with personnel lined abreast, under the direction of three search leaders equipped with portable non-tactical radio units (Fig. 2-11). A relay point for the radios was located atop a small peak in the vicinity of the Command Post. Each day search areas were laid out and instructions given to the personnel as to what type of equipment they were to look for. Maintenance personnel and aircraft investigation and disaster control teams were on the search, mixed with other personnel, so that anything spotted could be duly noted, identified, and reported to the intelligence specialists for plotting on maps.

During the first week there were no adequate maps on which to plot each day's search. Existing maps from Spanish sources proved to be inaccurate and did not show the village of Palomares. On 24 January the first of the mosaics prepared from the 18 January aerial reconnaissance arrived, and serious plotting of wreckage impact points and search areas could then be done.

As photo mosaics became available, search areas became more definitive, and coverage could be more accurately determined without duplication of effort. After technical theorists

* High Explosive

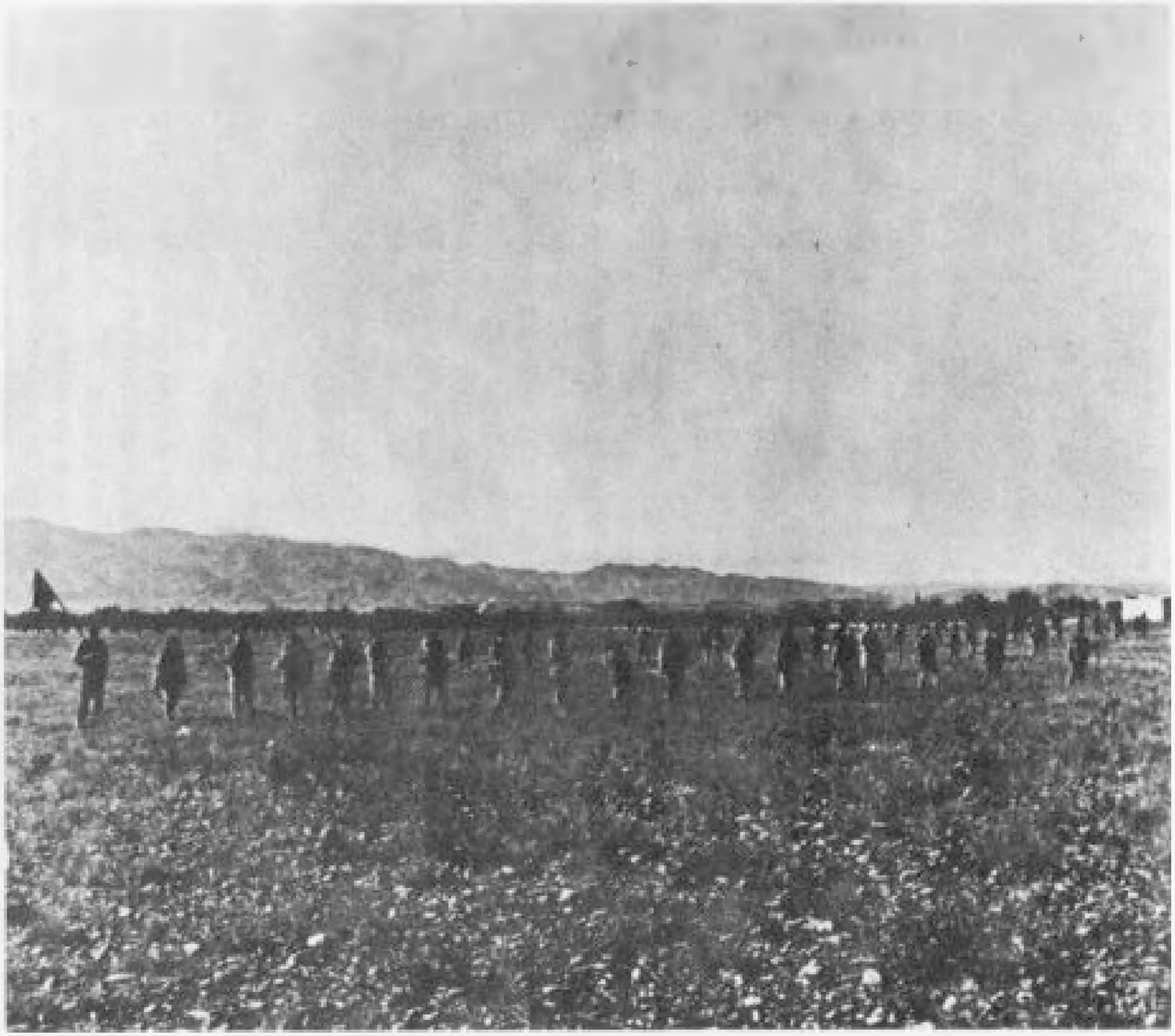

Figure 2-11 Searchers

in the Sandia Corporation had studied the report of aircraft track, wreckage pattern, the locations of the weapons that had been found, and the prevailing winds at the time of the accident, they requested that certain areas be searched and researched for possible location of parts of the fourth weapon.

North American Aviation offered the use of its newly-designed "Advanced Nuclear Detection" equipment for possible location of missing weapon components. This equipment was installed in a 16AF C-54 on 27 January and calibrated on 28 January. Search sorties were flown on 29 and 30 January in the area of the crash at very low altitudes (200 and 100 feet). Radiation readings were detected by the equipment in the areas of previously known readings. There were no new developments. The project was terminated and ground search continued.

Further theories regarding possibilities of a mid-air collision and detonation of the fourth weapon were advanced. In an effort to fix the location of the fourth weapon, Maj Gen Wilson requested that an analysis group be formed and furnished with all the data available at the site. A systems analysis team (SAT) of experts was formed of personnel from Sandia Corporation, Wright-Patterson AFB, and Eglin AFB. The SAT Theory which they developed offered several conclusions regarding Weapon #4. One of these was that the weapon collided in air with another object, resulting in an HE air detonation. A major part of the weapon continued in the general flight path of the aircraft, and the weapon case with attached parachutes deployed drifted out to sea. Ballistic trajectories were computed, and the area of probable impact received a thorough search for craters, wells, and mine shafts.

While many indentations were covered when the troops walked the fields and were checked for radiation and for any sign of disturbance, there were also numerous abandoned shafts, wells, and just plain holes that might well have hidden either the weapon or parts of it. While any such area was suspect during the first two weeks of the hunt, it was in early February that serious study of such places started. The men that were walking marked them with lemon-colored flags. They were then checked for radiation and for disturbed appearance that might indicate that some type of debris might have fallen there. They were plotted on maps, given serial numbers, and ticked off as either clear or as needing further study. Maj Gen Wilson asked USAF to provide him with a geologist who would be able to recognize deviations from the normal that might indicate a hiding place for the elusive weapon. The request was made to USAF on 8 February, OSD* approved it, and on 23 February Mr. Donald Kingery of the U.S. Bureau of Mines, Department of Interior, arrived at Torrejon, was given a briefing, and the following day went to the site via the early morning aircraft and the helicopter shuttle run.

Plotting of shafts and wells, as mentioned above, had started prior to his arrival. Some had been eliminated due to physical appearances, such as undisturbed grass or closed covers, but others had been listed as requiring further investigation. The daily log kept by Mr. Kingery listed 169 sites checked out, using criteria established at the site. The observations of the shaft walls were made to determine possible damage due to an impact, the bottoms were inspected for cratering. Where water existed, the

* Office of the Secretary of Defense

elimination was based on the shaft diameter and physical condition of the walls. The impact distances within the shafts were calculated for openings of varying diameters, of from 1 to 3 meters, for an object with an impact angle of 2 to 3 degrees from vertical, based on the estimated trajectory. This work went on until 3 March, and was concluded when all known locations had been surveyed as well as possible, this coincided with the period when decision was made to discontinue the ground search.

A test was conducted at White Sands Test Range to determine what a probable crater would look like in similar ground. Colored photos were airmailed to the site for visual briefing aids to the ground and air search parties. A total of 300 craters, wells, and mine shafts were identified, and a systematical search of each depression and/or hole was undertaken by Search Operations, assisted by personnel from Los Alamos and Sandia Corporation and the U.S. Bureau of Mines.

Ground search of the disaster area was one of the most comprehensive activities of the Broken Arrow operation. Two high probability areas were designated for primary search. One of these areas covered approximately 4 square miles, and the other, 2 square miles. Search leaders were briefed each night on the area to be covered the next day, and by 2 March the search areas had been covered in "finger-tip to finger-tip" line abreast formation, both longitudinally and laterally, an average of five times, and in some cases as many as nine times. As new information became available, new areas were identified and searched. Each night at approximately 1730 hrs, the search teams would return with bits and pieces of aircraft wreckage that had been overlooked, but nothing was recovered that indicated that the fourth weapon had impacted whole or that its HE had detonated and scattered over land. Each piece was examined nightly by the Los Alamos and Sandia Corporation personnel, and all pieces were identified as aircraft debris or equipment.

On 3 March, after intensive ground search of the entire area and thorough investigation and elimination of 232 soil depressions, mine shafts, wells, and reservoirs, a message was sent by Maj Gen Wilson to General Ryan recommending termination of the ground search. The message was coordinated and concurred in by members of the AEC and Sandia Corporation. The fact that all of the debris and material which had been collected and examined by USAF and civilian weapons specialists failed to substantiate a fourth weapon breakup and impact on land and the testimony of fishermen who were witnesses to the accident and who reported seeing what was obviously a 64-foot white parachute descend and sink into the sea left no doubt in the minds of the team and members of the search organization that termination of the ground search was in order. The AEC and Sandia Corporation personnel departed Camp Wilson to brief higher headquarters in Washington on 8 March and the CINCSAC* on 9 March. On 9 March, a message from CINCSAC to CSAF** concurred with Maj Gen Wilson's recommendation that the ground search be terminated, and on 10 March CSAF made the same recommendation to the Assistant to the Secretary of Defense (Atomic Energy), with the provision that the capability to regenerate a land search be maintained as long as there was a potential need for same.

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* Commander-in-Chief, Strategic Air Command

** Chief of Staff, U.S. Air Force

At that time the DOD established a charter for a Search Evaluation Board, with the chairman being Dr. Sproule of the research organization of the Secretary of Defense, and representation from the Department of State, AEC, Joint Chiefs of Staff (JCS), Chief Naval Operations (CNO), and USAF. The purpose was to evaluate the search effort and to prepare a decision on "when to conclude the search operations short of success." A briefing for the board was requested to be presented by SAC/16AF on 16 March, and two each SAC and 16AF officers went to Washington, D.C. for that purpose. They had all been at the site and were completely familiar with the entire operation.

At the time this presentation was being given, word had reached Washington, D.C. that the U.S. Navy had discovered a parachute-shrouded object on the ocean floor. While it could not be definitely determined that the object was the bomb since the chute could not be lifted from it, photographs and testimony of the Alvin crew made it almost a certainty that the search was over. Thus, on 18 March, Maj Gen Wilson said that the ground search was being suspended "pending further investigation and recovery operations of Navy."

Radiation Surveys:

Operations were conducted in terms of Counts Per Minute (CPM) on the PAC-1S. There is a discrepancy among the available reports as to the correspondence of CPM readings to surface contamination in micrograms per square meter. Dr. Langham quotes a correspondence of 13,000 CPM and 100 $\mu g/m^2$. Another report suggests an equivalence of 100,000 CPM and 1,000 $\mu g/m^2$. These equivalences fall outside of the PAC-1S specification which required linearity to within ± 10 percent. The manufacturer was contacted during preparation of this summary. Under perfect and theoretical conditions of a infinite thin source, the correspondence would be 11,250 CPM and 100 $\mu g/m^2$. Any self-shielding in the source or by ecological material would significantly change these figures and represents just one more difficulty in terrain monitoring with an alpha detector. Considering that Dr. Langham's figures were the basis of the first proposals, and that the slight (11,250 - 13,000) difference can be accounted for by variations in the distance between probe face and terrain surface, it seems reasonable to provide table 2-4 based on his estimates. The figures provided represent significant peg points used in the negotiations.

TABLE 2-4

EQUIVALENCES FOR PAC-1S AS EMPLOYED AT PALOMARES

PAC-1S (CPM)	Surface Level ($\mu g/m^2$)
100,000	770
60,000	462
10,000	77
7,000	54
700	5.4
500	3.8

Terrain:

By the evening of the day of the accident, 17 January, a small monitoring team equipped with PAC-1S portable alpha detectors was at the site. Weapon #1 was found and surveyed. No contamination was present - the weapon was intact. On 18 January, Weapons #2 and 3, both of which had suffered HE detonation, were located. The monitoring team, operating primarily in support of Explosive Ordnance Disposal (EOD) personnel, found that alpha contamination was generally present in the area. At Site #2* the tail section of the weapon had been displaced some 250 feet by the detonation. Readings on this weapon section "pegged" the instrument at 2,000,000 CPM.**

On 19 January 1966, first attempts were made to delineate the area and extent of contamination. On this date the remainder of the Torrejon Hazard Survey Force arrived to assist in monitoring. Priority was assigned to recovery of weapons parts over detailed area monitoring. The first function was to assist EOD personnel in their task, by providing local monitoring around the immediate crater areas. Radial line plots, however, were begun at the same time. Personnel and PAC-1S's were still somewhat limited. Because of this, on 20 January all monitoring activity at Site #2 was stopped. Site #3 was located on the edge of the village of Palomares, and the potential political implications of this were already suspect. The contamination was found to extend into the valley below the crater to a distance of approximately 4500 feet after 4 to 5 days of detailed monitoring. It included farms and cropland.

As at Site #3, the contamination at Site #2 was found to extend a considerable distance in the downwind (roughly east) direction and again included much cropland. A note on the survey report sheet of Site #2 for 19 January indicates that monitoring was stopped at that location after 15 minutes of work due to an instrument malfunction - no replacements available. Refinements of this contaminated area was finished on 10 February 1966. Monitoring in the villiage of Palomares, in conjunction with Spanish nuclear energy commission (JEN) personnel, was begun on 24 January 1966. This consisted initially of monitoring houses and random crop monitoring. By 3 February 1966, however, it was established that a pattern of contamination ran through the village and connected Sites #2 and #3, thus making one complete pattern.

* Site locations were numbered for identification purposes as follows:

Site 1: location of first weapon found;

Site 2: location of second weapon found, west of the village of Palomares;

Site 3: location of third weapon found, east of Palomares;

Site 5: village of Palomares, between and connecting Sites 2 and 3;

Site 6: east of river bed near B-52 tail section impact site; a continuation of Site 3.

** A PAC-1S will not read over 2,000,000 CPM, unless percentages of the probe face area are covered and the readings extrapolated accordingly. This was never done, however, because of time factors and no operational requirement for the information. The readings were recorded as "instrument pegged," or "+2,000,000." With the exception of small, fragmented areas, the terrain yielded few readings of this magnitude.

Initial radial lines around the two craters were run until readings of less than 1,000 CPM were found. The method of further definition of the contaminated area consisted of taking 6 to 12 readings in each field and averaging. This average figure was placed on a sketch, as no maps were initially available. In final form, this appeared as a rather jumpy and random plot of the contamination, but it proved to be a practical approach, particularly when decontamination actions commenced.

The initial surveys were never redone in total. Refinement of the contaminated area at later stages consisted on monitoring and flagging isolines of 7,000 CPM and above and 700 CPM and above (to conform to limits established during negotiations). These were then transferred to maps of the area. On 30 and 31 January 1966, a zero contamination line was run around the entire pattern and staked with red flags.

During the early days of the survey operation, it was obvious that the prevailing wind and the limited operations near the two craters were causing a shift in the contamination pattern. Plutonium was being resuspended from the ground. The total extent of the spread will never be known. Hindsight (that of a Health Physicist on the scene) suggests that an early effort to fix the heavy contamination near the craters would have paid dividends. Of course, the search for weapon parts in the same area was a competing activity.

Another contaminated area was located north of the village of Villaricos, approximately 4,000 feet from the eastern boundary of Site #3. The area was approximately 3/4 square mile in size. Contamination levels were low, the maximum being 7,000 CPM, with most levels in the less than 500 CPM range. This area is isolated, rocky, and contains no cropland. For this reason little concern was devoted to this area, other than delineation of the extent of contamination. The area was monitored jointly with JEN representatives and is believed to have been contaminated from Weapon #3, with prevailing weather conditions at the time causing the break in the pattern.

These radiation surveys were necessary to delineate the extent of contamination and to provide a basis for definition of the decontamination operation to follow. Terrain surveying was a continuing program during the operation. It required many man-hours of backbreaking work, extending from relatively easy terrain to that which was much more difficult. In the end, final surveys were performed on all decontaminated land before it was turned back to its owners. It was a difficult job performed under trying circumstances.

A hazard control line, as such, was impractical. The politics of the situation negated establishment of strict area control procedures and the placing of "contaminated area" signs. The low levels of contamination in most of the pattern did not actually make this necessary.

For initial weapons recovery actions, EOD personnel wore gloves, anti-contamination coveralls, and gas masks when working in the crater. Surgical masks were later found to be

more practical for this type of work.* Control points at the two areas of major activity, #2 and #3 craters, were established. Monitoring of personnel was routine and by 24 January a 500-gallon water trailer was in use at Site #3 for decontamination of personnel and equipment. By 27 January, a similar unit was available for Site #2; however, by that time major recovery actions at that location were complete. In the interim, decontamination was done by means of buckets and bags of water, brushes, and soap.

A shower was installed in the base camp on 25 January. This proved to be a great asset in personnel decontamination. On 3 February, a similar unit was set up at Site #3 for use by personnel working in the contaminated areas. Personnel involved in clean-up operations were issued protective clothing - gloves, coveralls, surgical masks, surgical hats and boots in accordance with standard procedures covering the various cleanup operations.

There was continuous air sampling to determine the significance of airborne contamination. Particular attention was paid to those operations which generated dust. Resuspension of the plutonium was negligible. Urine sampling of personnel was begun within three days of the accident. The initial samples were 24-hour volumes, but it was found that this was not practical, as it required personnel to carry the sample containers into contaminated areas (a logical reason for the high levels in some of the initial samples). This function was later given to the camp medics, to handle on a routine basis. Initial results from the Radiological Health Laboratory were encouraging, except for a few people who had apparently received extremely high body burdens. Cases subsequently proved to be contaminated samples. Repeat sampling indicated that no person received any significant body burden. JEN officials handled a program of urine sampling for Spanish civilians. Initial samples were collected on 30 Spanish personnel by U.S. personnel. Primary emphasis was placed from the beginning on urine samples as an indicator of personnel exposure. Other techniques included some nasal swabs and an early use of film badges. The film badges being sent to Wright-Patterson AFB for evaluation. To further control personnel radiation exposure and to insure that no contamination had been carried into the base Camp, the base Camp was monitored daily.

During the early stages, before the setup of showers and a base laundry, elimination of contamination on personnel and clothing was awkward and difficult. Proper decontamination of coveralls was not possible until 1 February 1966. Personnel showers were in use on 25 January; a laundry was installed on 31 January. Many personnel came to camp with only limited clothing, because they were told they would only stay for a few days. Developments proved

* It is doubtful that the use of the surgical mask served more than a psychological barrier to plutonium inhalation. These masks were not designed as filters for micron particulates nor do they fit to the face without leakage. An interview with one of those present at the site indicates that control of their use was not stringent. One would see them hung about the neck or perched atop the head as often as over the mouth and nose. It is significant in this regard that air sampling indicated a negligible resuspension problem. Had it been otherwise, it is probable that larger body burdens would have been registered. The masks were more comfortable than plutonium respiratory devices, that's all.

this to be extremely conservative. If contamination was found on the skin during personnel monitoring, individuals were instructed to wash the contamination off and be remonitored. If contamination was found on clothing they were instructed to change immediately and to wash the contaminated apparel. All personnel were informed of the importance of following these directions. Supervisors were instructed of the necessity of complying with these instructions. At later stages more exact precautions were possible, such as issuance of work clothes at each control point, and then removal at the end of the day. These clothes were monitored prior to being reworn.

An instance occurred when 7th Army minesweeper personnel arrived in Germany with some contamination on various articles, even though their equipment was checked before leaving Camp Wilson. This resulted in establishment of a firm program to insure that no one left the area exceeding permissible levels of contamination.

In summary, the types and the number of samples taken as listed in the final bio-environmental report, were as follows:

TABLE 2-5

ENVIRONMENTAL AND BIOLOGICAL SAMPLES, PALOMARES
17 January - 7 April 1966

Type	Number
Personal	
Urine	1,370
Nasal Swabs	109
Film Badges	22
Air	439
Water	
Locally Tested	75
Sent to RHL	22
Soil	43
Vegetation	
Beans, Cabbage, etc.	28
Tomatoes	74

Negotiations:

Negotiations on levels and methods of decontamination proved a difficult task, for there were varied opinions on what was acceptable. The Spanish government had not established criteria for permissible levels, which is completely understandable because plutonium-producing facilities and nuclear weapons were nonexistent in Spain. Significantly, there were no criteria in the United States for accident situations. The available criteria pertained only to plutonium processing plants and laboratories. There were, however, the broad guidelines established from the Nevada tests. A sense of urgency prevailed, primarily from a political standpoint, to arrive at criteria and begin the clean-up.

Dr. Wright Langham and other representatives from the AEC, Los Alamos Scientific Laboratory, recommended the following proposal for handling the contaminated areas; "Based on present information which is summarized in the 1 May 1963 training manual of the Atomic Weapons Group, the following procedures and activities seem quite adequate to control any possible lifetime hazards associated with Areas 2 and 3:

"1. All areas in which alpha counts per probe area are 100,000 CPM or above will be removed to a depth of at least 5-6 cm and buried in an appropriate pit which will not permit seepage into the water table.

"2. All areas with counts between 100,000 CPM and 7,000 CPM will have the present crops removed and buried. In all cases where the ground shows counts of 7,000 CPM to 100,000 CPM the soil will be sprinkled with water and plowed to a depth of at least 10 cm. After it is plowed, it will be sprinkled again and another monitoring survey conducted. Any spots that read above 7,000 CPM will be replowed and resprinkled until all readings are below the 7,000 CPM value.

"3. All areas reading between 500 CPM and 7,000 CPM will be sprinkled with water to leach and fix the activity in the soil to minimize spreading by the wind. After sprinkling, the areas that read above 1,000 CPM will be resprinkled."

This proposal was presented to the Spanish JEN for consideration. Although agreeing in principle with U.S. Air Force decontamination methods, they did not agree on the levels at which various types of decontamination actions would be taken. Several days of discussion and negotiations took place, and the following agreement was reached on 2 February 1966:

1. Select a place with adequate conditions to build a disposal pit where highly contaminated soil and products will be deposited.

2. Build the pit with proper safety provisions for public health.

3. Annual vegetable crops with a reading above 200 CPM will be removed to the disposal pit, buried, and decomposed with quick lime.

4. Fruit orchards will be carefully water-washed to remove all contamination.

5. The ground areas treated as indicated in paragraphs 2 and 4 above, will be remonitored after completion of water-washing operation and depending upon the level found at that time, one of the following three procedures will be observed:

a. Soil above 7,000 CPM will be removed and deposited in the disposal pit. Soil will be replaced to the extent to which it was removed and refertilized.

b. Soil areas between 7,000 and 700 CPM shall be wet down, plowed, and remonitored for contamination. If the count does not come down to less than 700 CPM, the soil will be treated again until less than 700 CPM is reached.

c. Soil areas below 700 CPM will be soaked with necessary water to bring contamination down to very low level and remonitored for reading.

6. All monitoring will be done with the PAC-1S.

It is significant to note that the clean-up criteria desired by the Spanish was considerably more conservative than that recommended by Dr. Langham. Although the Spanish agreed in principle to the U.S. proposal, the more stringent requirements were based on psychological reasons.

During the period 3 February 1966 to 1 March 1966 the following changes and/or amendments were agreed upon by the JEN and the U.S. Air Force:

1. On 4 February 1966, agreement was reached with Eduardo Ramos, M.D., Chief Health Physicist for the JEN, that watering, following plowing would not be a requirement. This decision was based on the fact that plowing followed by rototilling reduced the surface count to non-detectable.

2. On 8 February 1966, agreement was reached with Eduardo Ramos, M.D. (JEN), to permit hauling of harvested crops having a count of 200 CPM or less to the river bed for burning.

3. On 10 February 1966, agreement was reached with Eduardo Ramos, M.D. (JEN), to raise the counts per minute on harvested crops which could be burned to 400 CPM.

4. Changing attitudes on leaving the contamination in Spain resulted in negotiations being conducted by the U.S. Embassy and JUSMG-MAAG with their Spanish governmental counterparts during the week of 14 February 1966. There was considerable concern in both governments about leaving a "monument" to the accident in the form of a burial pit. These parties reached an agreement which, in effect, stated that only that soil having a surface contamination level of 60,000 CPM would be removed from Spain. (Plowing to a depth of 8

inches of an experimental tract of 0.09 acres which had a surface count of 40,000 CPM, followed by a second plowing to a depth of 4 inches, demonstrated that this procedure would maintain the surface contamination level at non-detectable.)

5. On 24 February 1966, agreement was reached with Lt Colonel Santiago Norena (JEN) to permit burial of the previously scraped and piled soil in Area 2 (with a surface count above 7,000 CPM but less than 60,000 CPM) in the pits which had been dug for permanent burial of the highly contaminated dirt.

Difficulty was encountered in applying the original criteria to hilly, rocky, uncultivated areas. This problem was resolved by a meeting at Camp Wilson on 28 February 1966, which had in attendance Generals Donovan and Wilson, Dr. Wright Langham (Consultant), Eduardo Ramos, M.D. (JEN), and other members of the JEN and the U.S. Air Force. The following agreement was reached and represents the last of the amendments to the agreements on decontamination levels and methods:

1. Follow-up cleanup requirements in the uncultivated land areas would be limited to Area 2. Earth would be removed from:

a. Hot spots which showed counts of 60,000 CPM or above. This earth would be included with that to be shipped from Spain.

b. Land surface showing counts in excess of 10,000 CPM would be washed, scarified, or dug up and raked.

c. Land surface showing surface counts of less than 10,000 CPM would be watered down where practical.

2. The permissible level of contamination was accepted as 10,000 CPM.

3. No work would be accomplished in Area 6.

This is a summary of the amended agreements concerning decontamination levels and methods employed at Palomares.

1. Soil above 462 $\mu g/m^2$ scraped and removed from Spain.

2. Soil between 5.4 - 462 $\mu g/m^2$ water, plow.

3. Soil below 5.4 $\mu g/m^2$ - water.

4. Soil below 77 $\mu g/m^2$ - permissible where other measures could not be applied.

In actual use, the pit at Site #2 was employed as a holding area only. The vegetation and scraped soil from other areas which was placed there was later barreled and removed from Spain. The pit was decontaminated and filled.

Implications of Decontamination Levels:

The stated policy of the U. S. Government in relation to the Palomares operation was to decontaminate to levels which were more than adequate by U.S. safety standards. The United States recognized that the Spanish Government desired levels far beyond safety requirements in the interest of combating psychological consequences of the accident. The chance that the decontamination levels agreed to at Palomares would be pointed to as "safety standards" should a subsequent contamination incident occur was a natural concern of U.S. authorities. Even though safety standards for plutonium decontamination exist, their employment in future incidents will probably be used as a talking paper for negotiations - a starting point to be overridden by psychological and political concerns.

Decontamination:

Once the areas of contamination had been defined, removal of contaminated crops and soil started. To keep track of the work in the contaminated areas, they were divided into plots, basically following the outlines of the fields and gardens. These 844 plots covered 385.68 acres, with contamination readings running from 0 to over 100,000 CPM. Within this area there were demarcation lines for areas of less than 60,000 CPM where decontamination was to be accomplished, while the areas above that level was to have the soil removed.

Vegetation was also marked since that vegetation under 400 CPM could be burned. Subsequently 3,970 truckloads of vegetation (at 4 cubic yards per truck) were hauled from the area and destroyed. For the remaining contaminated areas, both soil and vegetation, leaching by watering, and washing down was accomplished to reduce readings to as low a level as possible.

Eleven days after the accident, the JEN, AEC, and engineers discussed the location of a temporary burial or storage facilities and agreed on an area at Site #2. Using the construction equipment that had been brought in originally to build a road to the impact sites and handle the wreckage, a temporary pit was dug. This pit was a trench-silo type with an approximate 1,000 cubic yard capacity constructed so that trucks could be backed up to it for unloading (Fig. 2-12). It was to this area that the debris went while awaiting decision on its disposition. As there was only a very small amount of the nearby area used for gardening and there were no houses in the immediate vicinity, no problem existed in using that spot. Upon completion of the disposal activity it was filled in by returning the dirt that had been excavated during its construction.

The crop removal activity started on 22 January, plowing (Fig. 2-13) and scraping on 27 January. As the work was in progress, dust control was accomplished by use of water spray (Fig. 2-14) or light sprays of diesel oil, with the latter being used primarily on highly contaminated areas. Roads were sprayed to prevent truck traffic from spreading

Figure 2-12 Temporary Burial Pit

Figure 2-13   Plowing Operations

Figure 2-14 Wetting Down Contaminated Area

contamination. To further guard against contamination spread, the truck beds were equipped with wooden boxes with a hinged flap on the back of the box that was closed during time of movement. By 10 February, the equipment in place to do this work included:

16 water distributor trucks
11 dump trucks
3 road graders
2 bulldozers
2 front end loaders (2 cubic yard buckets)
5 gang plows
5 soil mulchers
3 tree limb shredders

In a normal day of operation, 140 truckloads were moved either to the burning area or to the storage location. The area for burning was at the dry river bed near the impact point of the B-52 tail. This operation was accomplished at night when winds were toward the sea. In late February this area was moved closer to the shore and a new road was completed from Site #3 to the beach, avoiding inhabited areas.

Harvesting was a matter of pure physical labor. Machettes were requisitioned from Gray Eagle supplies to cut tomato and other crops. As tomato crops required cane poles for their growth, three tree-limb shredders were requested from and purchased by SAC. The first of which arrived within 24 hours from the time it was requested, on 2 February. Cane poles were pulled from the ground, shredded, and the remains loaded into the trucks for delivery to the storage site (Fig. 2-15; 2-16).

Soil removal was accomplished by the use of road graders, where possible, with it first being moved into windrows, and then into piles and finally loaded into trucks. Where graders could not be used, as in the isolated, hilly area around Site #2, the work had to be done by hand. When scraping left small hot spots, plowing and/or hand removal was necessary. For low contamination, scarifying of the soil, with minimum turnover, dropped the count to an acceptable limit. This minimum movement of surface area was primarily important in Site #2 where it was feared that major movement of top soil in the fragile area would create a dust bowl.

Constant monitoring by the PAC-1S was necessary to detect contamination spread, but, in general, no problems were found. Occasionally a truck would turn up with positive readings and would require washing down. Operators of scrapers and plows were mostly unaffected, while personnel using shovels at times had some contamination on shoes, gloves, and.outer clothing.

Washing of three buildings and some fences started on 30 January. Other buildings were washed but in cases this was not sufficient to lower the contamination level to the acceptable limit, and whitewashing had to be done. Rock wall fences were washed, and

Figure 2-15   Crop Cutting

Figure 2-16 Mulching and Loading

where vegetation which defined boundaries had been removed, either markers or walls of concrete block or tile were constructed to mark divisions. Hot spots on embankments of the irrigation ditches were washed down to below 500 CPM.

The zero-count line surrounding the contaminated area at Site #2 was defined by 31 January, and by 2 February the 7,000 CPM line had been marked. The area of 7,000 CPM covered approximately 35 acres. Constant monitoring permitted establishment of the 100,000 CPM area by 10 February, consisting of about 4 acres. Scraping of the soil, and/or plowing, was started on 1 February. Vegetation removal started on 2 February. Although no one record exists of the number of truckloads hauled to the burial site, it was estimated to be approximately 400. About 470 truckloads of crops were hauled to the destruction site for burning. Use of water at this area was at first difficult since there was a road only to the crater area, and not through the area. At first a fire truck was used for washing purposes since the pumped stream would reach the desired distance. Later, regular water distributing trucks with spray bars were used. As crops and soils were hauled away, the zero line was moved, and by 6 March all cane and vegetation as well as the soil over 60,000 CPM readings had been removed.

Site #3 was located at the edge of the village of Palomares, with the area over 7,000 CPM being about 11-1/2 acres, of which approximately 10-1/2 acres were cultivated. The area over 100,000 CPM was established by 10 February as 1-1/2 acres. Removal of crops started 22 January and was completed by 28 February, with 2,815 truckloads being burned and about 165 going to the disposal trench. Removal of the soil started about 1 February and completed by 5 February. By 7 February the first land was returned to the owners.

Site #5 was identified on 2 February, consisting of approximately 9-1/2 acres. The contamination level was not as high, and cleanup procedures were not as difficult. Crop removal was completed by 18 February, with 402 truckloads taken to the burning area. Plowing was done the following day, and by 24 February all land had been declared acceptable for use and returned to the owners.

The contamination spots at Site #6 were found on 4 February, and by 16 February a zero line had been marked. Some question arose as to the origin of the radioactivity, and U.S. Air Force asked that samples of the soil be sent to the AEC. Due to the rocky terrain and the sparse soil covering, machettes were used to shave off a layer of soil, and in that manner usually less than 1/2 inch could be removed. A total of 12 samples were taken with surface readings varying from 500 to 2,000 CPM. At one time there had been a mining operation here, and one of the samples was taken from an old ventilation tunnel of the mine.

Tables 2-6 and 2-7 indicate the general extent of the decontamination operation.

TABLE 2-6

LEVELS OF CONTAMINATION*

Area #2

1. 60,000 to over 100,000 CPM**	4 acres
2. 7,000 to 60,000 CPM	32 acres
3. Highest reading (soil contiguous to weapons chunks reading 2×10^6 CPM)	1.5×10^6 CPM

Area #3

1. 60,000 CPM to over 100,000 CPM Some areas between 7,000 and 60,000 CPM included.	1.5 acres
2. 7,000 to 60,000 CPM	9.5 acres
3. Highest reading (on 25 Jan. 1966 at 30 ft from crater)	700,000 CPM

Area #6 (Village of Villaricos)
(~1.0 mile ENE of Site #3)

1. Range of values within village	low hundreds CPM
2. Highest (among some rocks southwest of village)	5,000 CPM

Total Areas

1. Within zero line	630 acres initially 650 after winds occurred
2. Within 700 CPM line	500 acres
3. Between 7,000 CPM and 60,000 CPM lines	41.5 acres
4. Within 60,000 CPM line	5-1/2 acres
5. Above 7,000 CPM	47 acres

* Some apparent overlap among the data, probably due to varying levels within a given isopleth.
** 130,000 CPM corresponds to about 1,000 $\mu g/m^2$ - the DOD safety criteria for surface contamination.

TABLE 2-7

GENERAL POINTS

Soil - removed	1088 cubic yards from 5-1/2 acres
Soil - plowed: all cultivated land above 700 CPM	285 acres
Soil - watered: (20 Jan - 10 Mar)	285 acres
water use	100,000 gal/day
(During prolonged high winds fuel oil sprayed on stored material)	
Vegetation: (a) removed, mulched, stored (400 CPM or higher on vegetation)	400 yd^3
(b) burned (less than 400 CPM on vegetation)	3,700 truckloads (2 1/2-ton dumptrucks)
(c) all removed from areas where soil was above 700 CPM	285 acres

The Soil Shipment:

As discussed previously, soil with greater than 60,000 CPM and vegetation with greater than 400 CPM were to be removed from Spain. Although several methods of movement were considered, it was decided to place the waste in 55-gallon barrels. The barrels were fabricated by a contractor in Naples, Italy for delivery by 9 March. On 23 February, the plan for removing the debris was firm enough that DOD summarized it as follows:

Sixteenth Air Force has collected approximately 1500 cubic yards of contaminated soil and vegetation for removal from Spain. This will satisfy removal criterion agreed to by Government of Spain (GOS).

Sixteenth Air Force proposed the use of oil drum-like containers. Number required is 5,500, and these have been contracted for in Naples, Italy.

CSAF has arranged with CNO for pickup of drums by the USNS Card and delivery to Cartegena as soon as possible after production of drums is complete.

After filling, containers will be shipped to destination to be specified, but probably near Charleston, South Carolina, for rail shipment to, and disposal in, an AEC disposal area.

The delivery of the drums to Cartegena was opposed by the 16AF since it would then be necessary to transport them overland to Palomares, followed by carrying them back to Cartegena. Air movement of the empties was also considered, but since such aircraft as the C-124 could only carry 200, this was impractical; and, with San Javier as the nearest airfield, there would still be an over-the-road movement. DOD also pointed out that due to the sensitivity of this situation and the urgency of the matter, that "overland transport in Spain of contaminated debris should be minimized." It was suggested that if the barrels could be delivered by the Navy directly to Palomares, then the Navy could also pick them up there. The Navy was then asked to arrange such service. However, 200 of the drums were airlifted to San Javier and trucked to Palomares to permit testing.

Consideration was given to using either the SS Alma Victory or the USNS Cammon for movement of the empty barrels, with the USNS Boyce for transportation of the filled barrels to the States. None of these ships could load at the temporary pier at the beach, and landing craft would have to be used for lighterage (Fig. 2-17). The Alma was ordered from Suez to Naples, loaded the drums, and sailed for Palomares 1500Z, 9 March. The Boyce was routed Aden-Suez-Palomares, and arrived on 17 March. The U.S. Army's 1418th Transportation Terminal Unit, Cadiz, Spain, was given the task of handling the barrels from ship to shore and back again. A Military Sea Transport Service representative was assigned to duty to assist this operation. The Navy had one LCU and LCM6 and two LCM8 for use in shore-to-ship movement.

For the movement back to the States the Navy requested:

Dunnage, lashings and stevedores for shipboard handling, stowing, and securing of cargo.

One radiological survey team with proper radiac equipment to escort and monitor barrels while in transit to CONUS.

The need for a courier to accompany the shipment could be avoided if:

Each barrel were painted with consecutive numbers,

The words "Poison Radioactive Material" were painted in blue or red on the top, bottom, and sides of each barrel.

The 16AF did not feel that the labeling was in line with the spirit of the operation: minimum attention to the shipment. Also, since the barrels were being carried on Navy ships such warnings would not be required, at least until the barrels reached the United States and were prepared for overland shipment. Thus guidance from DOD was requested. DOD settled most of the questions by stating that due to the sensitivity of this shipment and the fact that no health safety hazard existed from the containers:

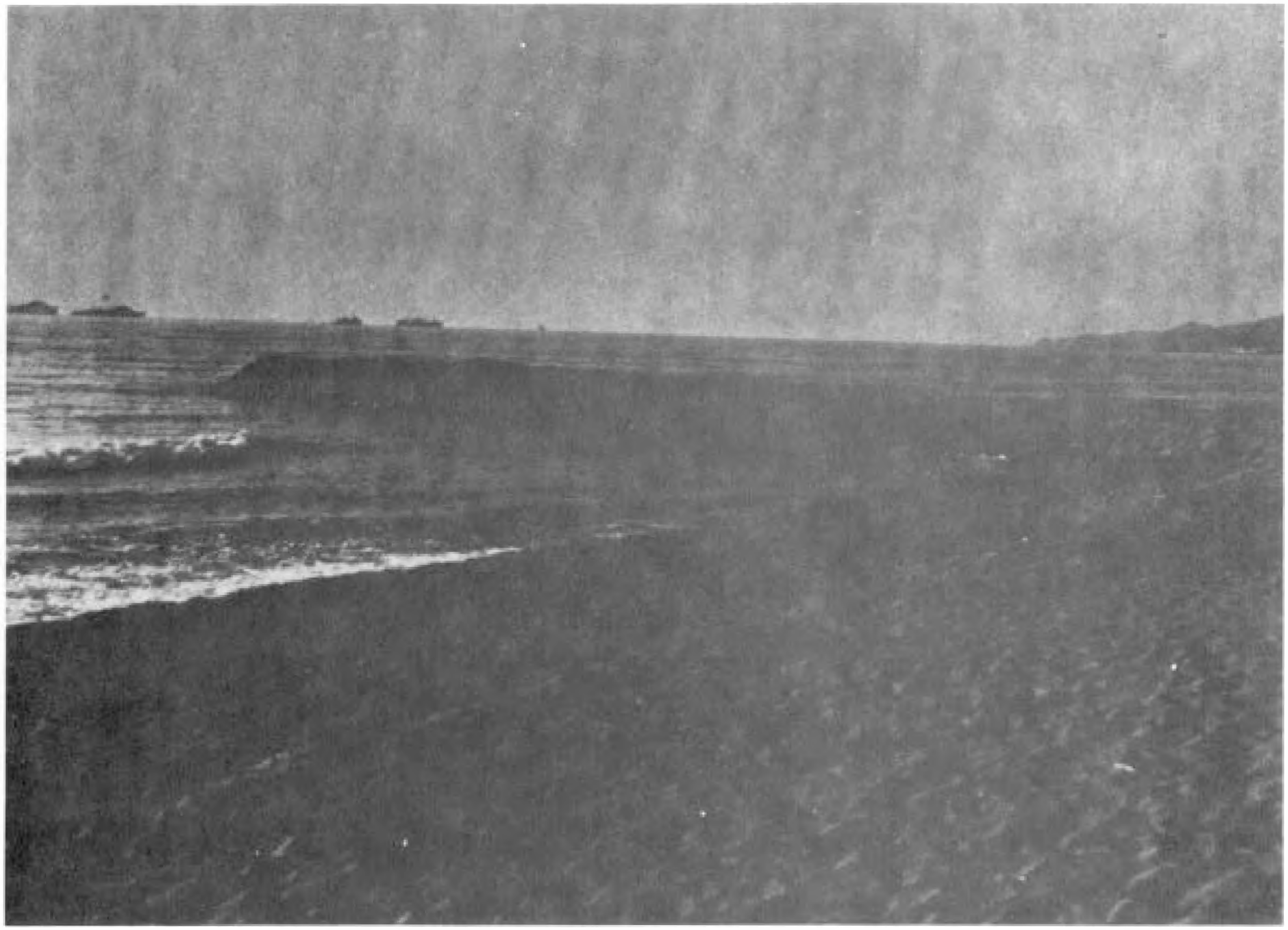


Figure 2-17 Camp Wilson Temporary Pier

Basic guidance continues to be to minimize visibility of the subject activity. Although it is recognized the soil removal task will be in full public view, the use of photogenic marking with scare words would seem to be unnecessary advertising.

Standard radiation warning markings will be required for common carrier in CONUS rail shipment. These, however, can be affixed at CONUS dockside.

In regard to the radiation monitoring team, the CNO was asked to comment. Navy decided that the barrels should be monitored before and during loading, and aboard ship during and after unloading. If that was done, no team would be required.

The Savannah River Facility, Aiken, South Carolina, was named as the receiving location. The docking site was to be the U.S. Navy Ship Yard, Charleston, which was to be responsible for:

Working on a 24-hour basis;

offloading 5300 sealed 55-gallon metal drums containing Spanish debris from USNS Boyce;

steel strapping 4 drums to a pallet;

loading drums into railroad cars and blocking/bracing cars as required.

The AEC would support by:

supplying 1,530 wing type hardwood pallets, 48" x 48";

arranging for about 30 railroad cars;

arranging for customs, agriculture clearances, and radiation monitoring services;

couriers to escort rail shipment to Augusta, Georgia;

reimburse expenses incurred in Charleston yards.

After these preparations, the filling operation began. Sixty-five airmen were sent from Moron and Torrejon to augment the camp force, including 12 carpenters, 3 welders, and the remaining 50 to work at filling and handling the barrels (Fig. 2-18). Personnel manning the shovels wore respirators or surgical masks, white coveralls, head coverings, and gloves. As each barrel was filled and covered, its sealing ring was affixed, the bolt tightened and welded in place, and two bands, placed at right angles, were spot welded into place. Each was checked for contamination at approximately 72 points, 12 on top, 48 on sides, and a

Figure 2-18 Barrel Loading Operations

final 12 on the bottom, before the barrels left the filling area (Fig. 2-19). A flatbed transported them to the beach, where radiation was spot checked. A roller conveyor system was used to move the barrels to the ships, with a square of plywood under each to permit easier moving. The goal was to move one barrel off the assembly line each 40 seconds (Fig. 2-20). It was found that only a very brief contact of the PAC-1S was needed to show if contamination existed; thus, with two monitors working top and sides, and a third for the bottom readings, the goal could be accomplished.

Four shifts of workers were used to fill the drums: 0600-1000, 1000-1400, 1400-1800, and 1800-2200 hours. Until the shredded vegetation supply ran out, the barrels were filled about 1/3 full with vegetable matter, and the remainder with soil.

When on 11 March, the SS Alma Victory arrived, the 200 barrels that had already been air-shipped were filled and waiting on the beach. Since the Alma arrived late in the afternoon, it was not until 12 March that the first barrels were off-loaded. The USNS Boyce arrived on 17 March. Some delays were encountered due to weather, and, at times due to the unavailability of LSU's or LCM's for carrying the drums to the Boyce; however, all work was completed by 24 March, as shown in Table 2-8. No radioactive contamination detected during entire operation. Appreciate outstanding cooperation/assistance Mr. Bastin/Mr. Hopkins and other AEC representatives.

TABLE 2-8

FILLING, LOADING, CONTAMINATED MATERIAL, DRUMS, PALOMARES
11-24 March 1966

Date	Empty On Beach	Filled On Beach	Aboard USNS Boyce
March 11		200	
12	3000	580	
13	5500	1214	
14		2221	
15		3180	
16		4062	
17		4810	
18			1550
22			3240
24			4810

At 241205Z March, the last barrel was moved off the beach, and at 1600Z the USNS Boyce sailed to arrive at Charleston at 052100Z April. Subsequently, USNS Boyce reported:

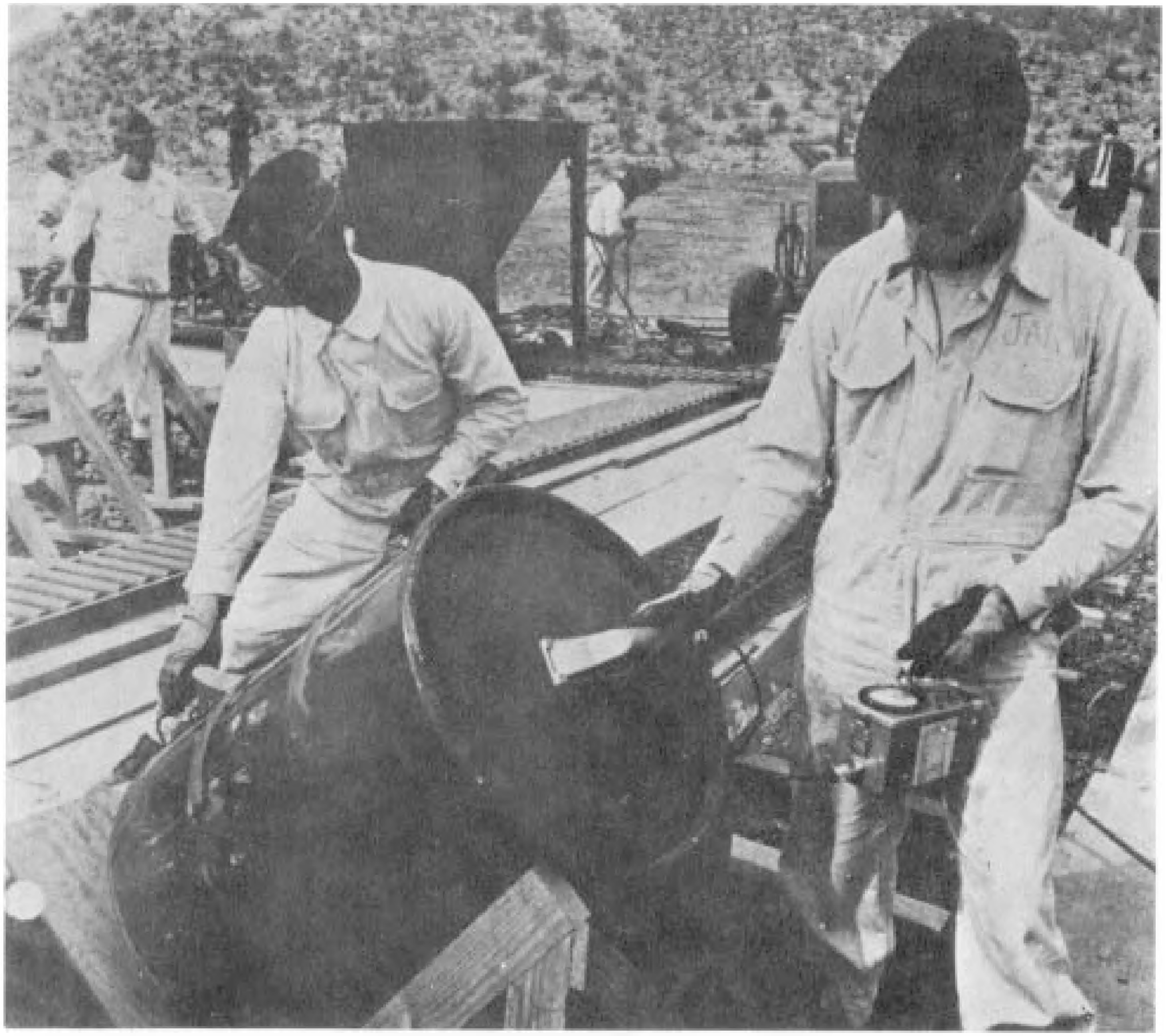


Figure 2-19 Monitoring Barrels

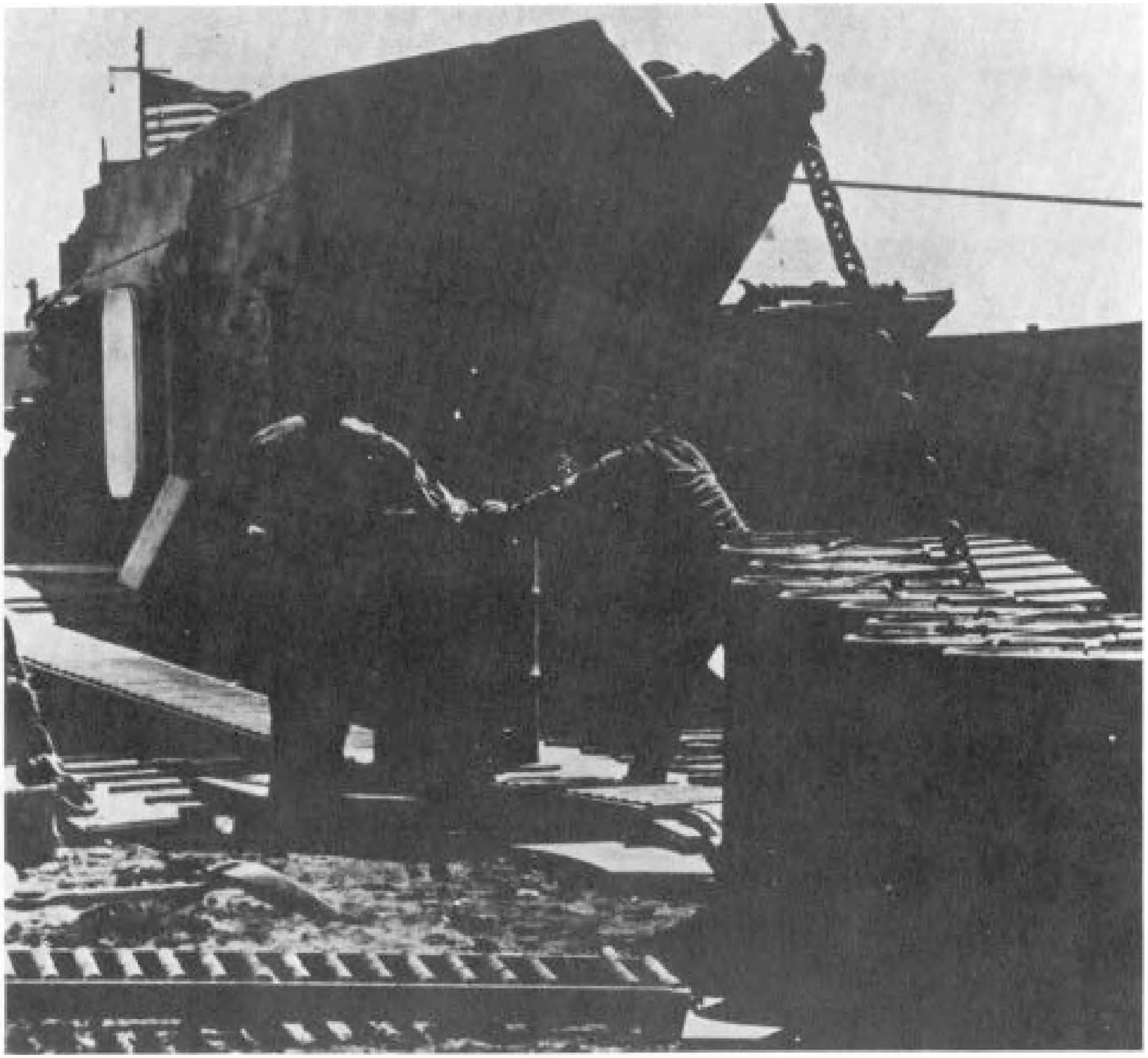


Figure 2-20 Barrel Loading Operations

Inspection by AEC representatives revealed drums arrived in satisfactory condition and off-loading from Boyce completed 060700Z. USNS Boyce departed Charleston 062300Z.

Completed loading drums into railroad cars 071040Z. Twenty-six cars accompanied by two AEC couriers in the caboose scheduled to depart Charleston 080130Z via Atlantic Coast Line Railroad, estimated time of arrival, Dunbarton, South Carolina, 081200Z.

From the accident site a summary of the contamination readings was sent to AEC. None of the drums showed exterior contamination, with the material in the drums carrying readings varying from zero to 300,000 CPM, with most of it at levels well under 40,000 CPM. Drums with soil that had come from an area of particularly high readings could not be identified since the moving and mixing process had caused a loss of identity. Two of the barrels were destined for Los Alamos, for Dr. Langham. They had been requested for research purposes. This left 4,808 for disposal in the trench grave prepared at the disposal site.

At the accident site the completion of this second phase of the disposal activity permitted release of 147 personnel from Camp Wilson for return to their home stations.

Return of the Land:

As the land was cleared of contaminated soil, some of the top soil was replaced, with the primary source being the dry river bed near the camp. As other areas were plowed and/or washed down to zero readings, the land was monitored by the U.S. Air Force and JEN, who agreed on its cleanliness and turned it back to the owners. Seven local tractors were rented for the plowing and harrowing, and a local farmer was put in charge of the operation. Some complaints were made on the results, primarily that the land was not left in a uniform level condition. Thus, some of this was reworked with the owners present and remaining until the job was completed on each plot. By the evening of 1 April all land within the contamination zone had been placed in the condition desired by the owners. All damaged culverts, irrigation ditches, bridges, concrete block fences (which replaced some of the cactus fences that had been removed), had been replaced, painted, repaired, or whatever other work was required to return the countryside to its original condition. On file in the City Hall of Cuevas De Almanzora was a map showing the plots of the land. From this map, each area was identified, and a Certification of Decontamination Action was prepared to show the method of decontamination, the date, and it was signed by both the JEN and the USAF representatives. This was an unofficial record used as a file copy by the two agencies. Next, a document was prepared that returned the land to the owner, with this also being signed by both JEN and U.S. Air Force, as well as the Spanish agronomist at the site, and the two commanders. The forms are shown on the following page. These were filed with the claims office of the Judge Advocate; one copy went to the land-owner, and one to General Montel, the Spanish commander for this project. A total of 856 were prepared.

DOCUMENTS FOR RETURN OF LAND TO OWNERS, SPAIN
February 1966

DOCUMENT I

Certification of Decontamination Actions

Removal of contamination from Plot ____, Site ____, has been accomplished as of __________. The method of decontamination was ____________. The undersigned jointly certify that this plot was monitored by JEN and USAF Representatives on __________, and the surface was found to be free of contamination. The monitoring instruments were calibrated PAC-1Ss, manufactured by the Eberline Instrument Company, Santa Fe, New Mexico, U.S.A. Monitoring was done by placing the probe face in direct contact with the surface.
JEN Representative ____________________. USAF Representative ____________________.
I certify that this plot can be returned to the landowner(s) for his use.
Date _______________

DOCUMENT II

In Palomares (Almeria) on _____ of ________ 1966 the following were present ____________ _________________ representing the Sixteenth Air Force of the United States, and ________ ____________ as a member of the Nuclear Energy Commission of Spain, and Mr. ________ ____________ as a representative of the Department of Agriculture of the Province, and were in complete agreement. THEY DECLARE AND CERTIFY: That the contamination may be considered eliminated as of the date of this document in the property ____________ identified in the map which is on file in the City Hall of Cuevas de Almanzora with the No. ________ zone __________, the decontamination having been accomplished by plowing, irrigation and grinding, and was tested by the Nuclear Energy Commission of Spain and by the North American technicians on ____________. The instrument was the PAC-1S, made by the Eberline Instrument Company of Santa Fe, New Mexico, U.S.A., and the testing was done by direct contact with the surface of the ground. That with respect to the condition of the fertility and safety of the land in question in this document, at this moment, the same conditions exist as were present prior to the 17th of January 1966 and such land should be returned at this time to its owners for normal use. And to go on record, we herewith issue and sign this document in quintuplicate for this purpose with the approval of the Commanding General of the Zone, as well as the Commander of the United States Air Force in the place and date indicated above.

____________________ ____________________ ____________________

Representative, NEC

Representative, USAF

Representative, Department of Agriculture, Province of Almeria

Approved ____________________
Commanding General of the Zone

Approved ____________________
Commander, Sixteenth Air Force

SECTION 3

SEA OPERATIONS

BACKGROUND:

Situation:

At 0922Z, on 17 January 1966, the collision of an Air Force B-52 SAC bomber and a KC-135 Tanker aircraft caused some 250 tons of debris to plunge to the surface of the earth in the vicinity of a Spanish hamlet called Palomares. Because of the proximity of the collision point to the coastline (Fig. 3-1) and the prevailing wind conditions, much of the debris fell into the Mediterranean Sea. The purpose here is to summarize the actions that resulted in the at-sea search, identification, recovery and wrap-up of Aircraft Salvage Operations Mediterranean (AIRCRAFT SALVOPS MED).

Authority:

In response to a verbal request from the Sixteenth Air Force Command for search and rescue assistance, the Commander in Chief, U.S. Naval Forces Europe directed Commander, Sixth Fleet to send a ship to the area. As a result of this order, a fleet tug (Fig. 3-2) arrived off Palomares just 7 hours and 8 minutes after the accident. Since the recovery of survivors by Spanish fishermen had occurred several hours previously, the Navy ship was released by the Air Force on-scene commander the following day. However, since only three of the four hydrogen bombs carried by the B-52 could be located ashore, the Air Force requested Navy participation in an at-sea search and the recovery of the debris resulting from the collision. Again, Commander, Sixth Fleet, responded, this time by ordering three ocean-going mine sweepers and a four-man EOD team to the area. This contingent was only the forerunner of the eventual thirty-four vessels that were to be manned by some 3425 civilian and military personnel. This task force was to be augmented by an assortment of four manned submersibles, three unmanned vehicles, and numerous systems designed to aid in, the search, identification, and recovery of objects located on the ocean floor.

Meanwhile, the DOD took action within its means to provide the necessary support to insure that the missing weapon would be recovered in the most expeditious manner possible. The Assistant to the Secretary of Defense (Atomic Energy) requested, through the Assistant Secretary of the Navy (Research and Development) that the Navy use all means to accomplish the task before them. On Sunday, 23 January, the CNO established AIRCRAFT SALVOPS MED and directed mobilization of Navy resources to assist in the search and recovery of the lost nuclear weapon. Since the Navy is responsible for the disposal of explosive ordnance discovered within the ocean, the task of locating the missing weapon was set about in earnest.

In the main, the CNO order resulted in two primary actions, one on site and the other within the Naval establishment. Task Force Sixty Five was organized from the assets of the Sixth Fleet. Rear Admiral William S. Guest, USN, Deputy Commander, Naval Strike and Support

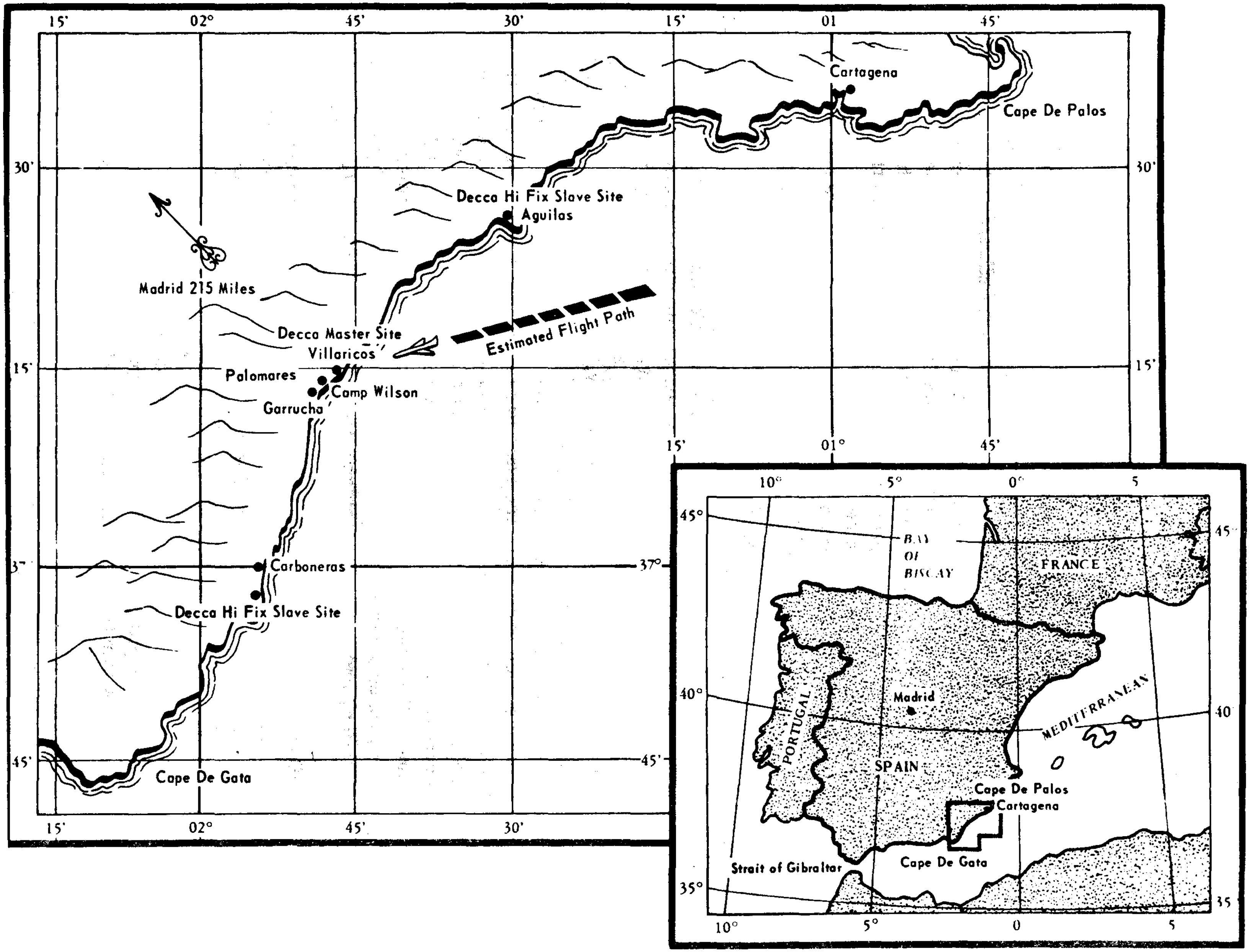


Figure 3-1 Southeast Spanish Coast

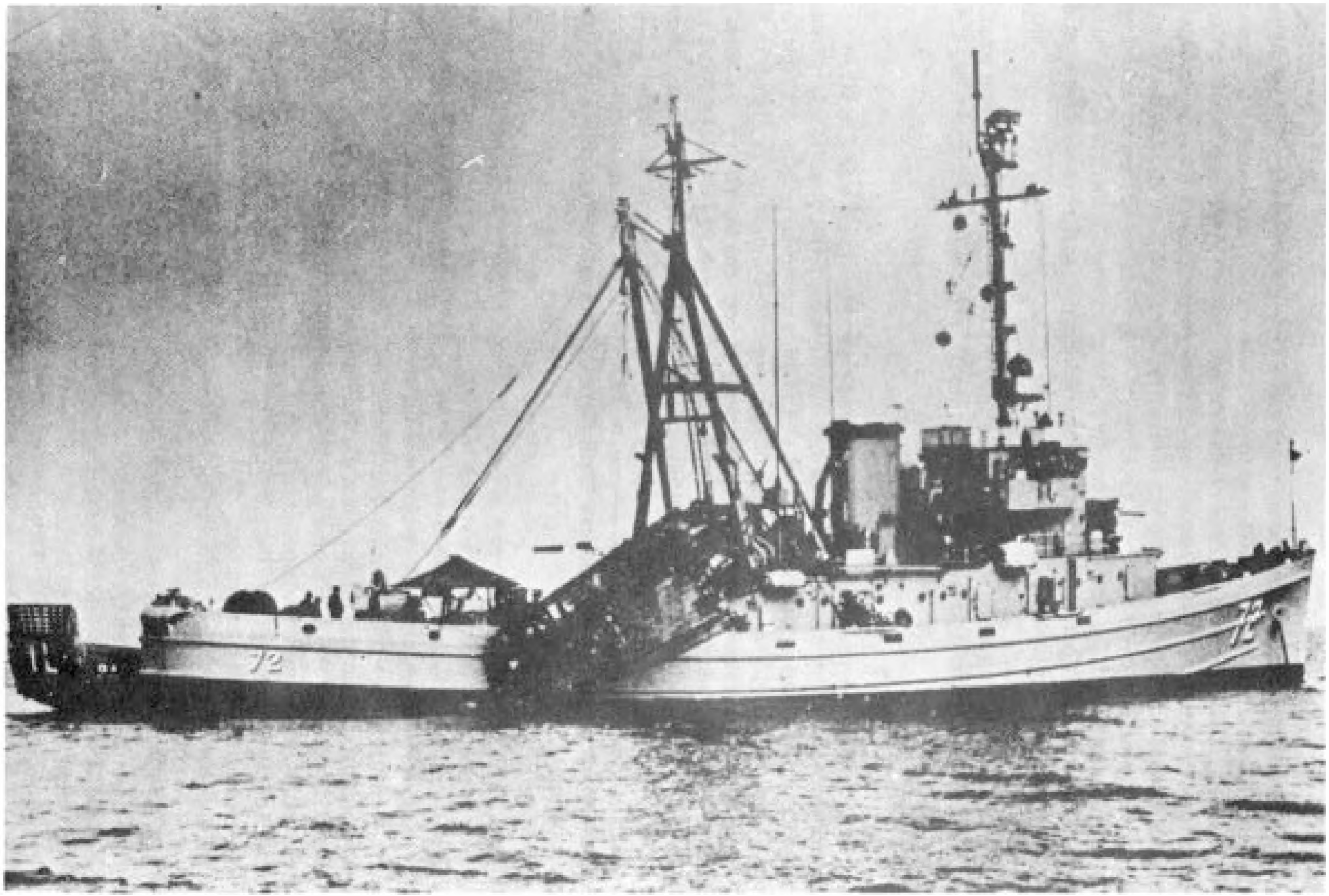


Figure 3-2 Fleet Tug

Forces, Southern Europe, was selected as the Task Force Commander (CTF). At the same time a Technical Advisory Group (TAG) was formed under the chairmanship of Rear Admiral Leroy V. Swanson, USN, Assistant Chief of Naval Operations (Fleet Operations)/Director Fleet Operations Division. The TAG consisted of representatives of those elements within or close to the Naval establishment who were most knowledgeable in the field of deep submergency capabilities and environmental problems. The mission of these established organizations was to support and "... conduct coordinated surface and subsurface operations in the vicinity of Palomares, Spain, in order to detect, identify, and recover material associated with the aircraft collision."

This task was to keep both groups at maximum effort for the next 75 days when finally the lost weapon was found, placed in its shipping container, and returned to the United States.

ORGANIZATION:

As with most emergencies or accidents, the military establishment was prepared for such an occurrence with contingency directives to be instituted through the chain-of-command. Before this accident, no weapon had been lost at sea in what could be termed foreign territorial waters. Consequently, the normal chain of command was modified as shown in Figure 3-3 to include representatives of particular interests of both the Secretary of the Navy and the Secretary of State. Once the available information had been passed to CTF-65 by those responsible in the 16AF, the at-sea operations proceeded with little dependence upon the land operation. In fact, from the outset, Naval participation was geared to the assumption that the fourth nuclear weapon was lost at sea, so that the eventual conclusion by the Air Force that the weapon was not on land had little direct effect on the tempo of operations of the sea searchers.

The development of TF-65 was slow and at best piecemeal. Very early in the effort, minimum requirements for the task force were estimated, and ships at least partially equipped for the specialized operations were assigned. Some were involved with maintenance overhaul cycles and so could not get underway immediately for Palomares. As the sea search effort continued with forces immediately available from Sixth Fleet, the TAG laid the highest priority upon procuring the military and civilian expertise in the field of deep sea recovery as well as much of the equipment and instrumentation suggested by these experts. As these personnel and materials filtered in by sea and by air, CTF-65 began to fill the slots of his final staff organization (Fig. 3-4). The initial source of personnel was from the complements of the ships on station. For the most part, the personnel in similar billets aboard the Flag ship were asked to double as the appropriate staff members.

The CNO had directed that full and precise documentation of AIRCRAFT SALVOPS MED would be required should the search be unsuccessful. These records would provide proof of the effort expended and justification for terminating short of success. On the brighter side, such information was considered to be useful for application in future development of procedures, vehicles, and equipment. To accomplish this task, a tactical analysis group, composed of four naval officers and three civilian analysts, was ordered to report to CTF-65

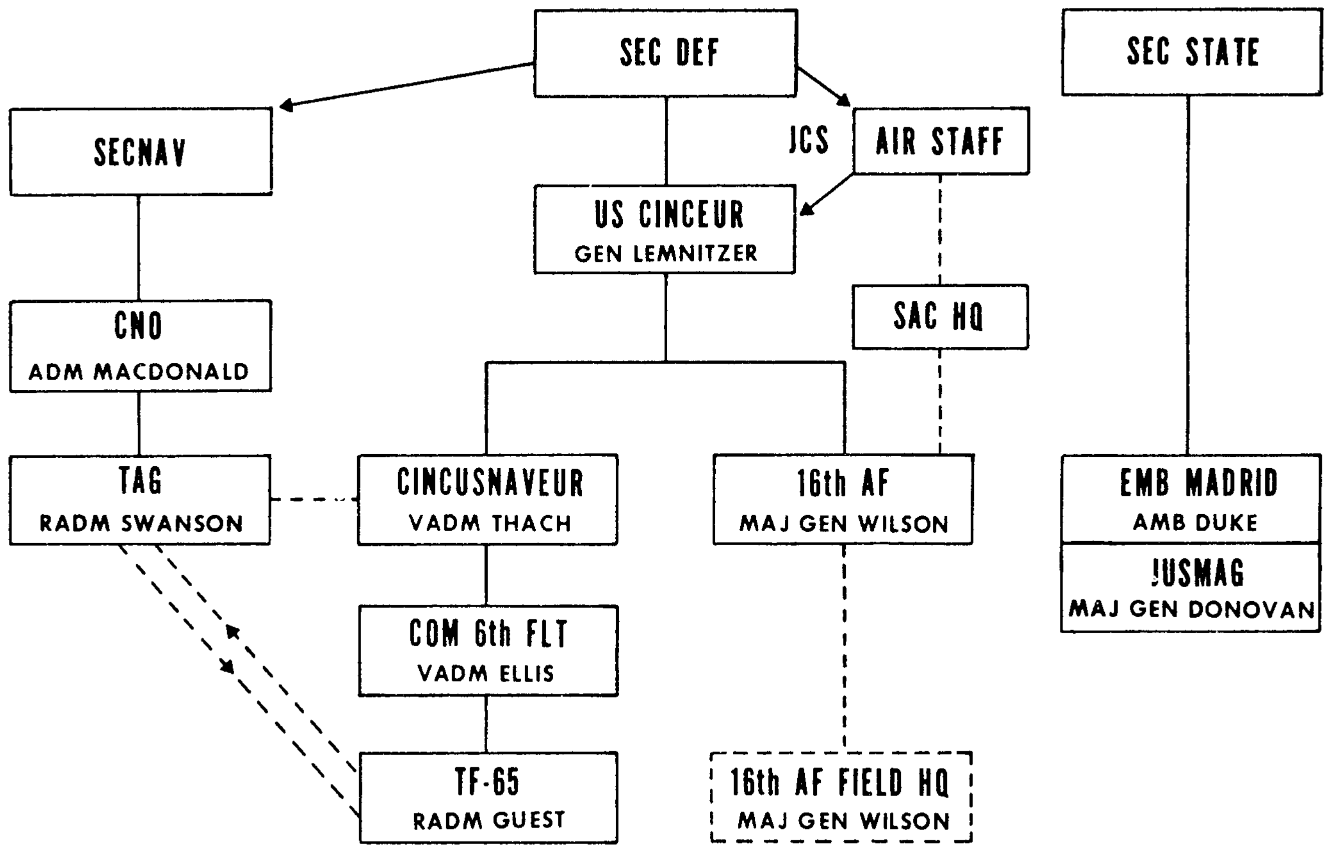
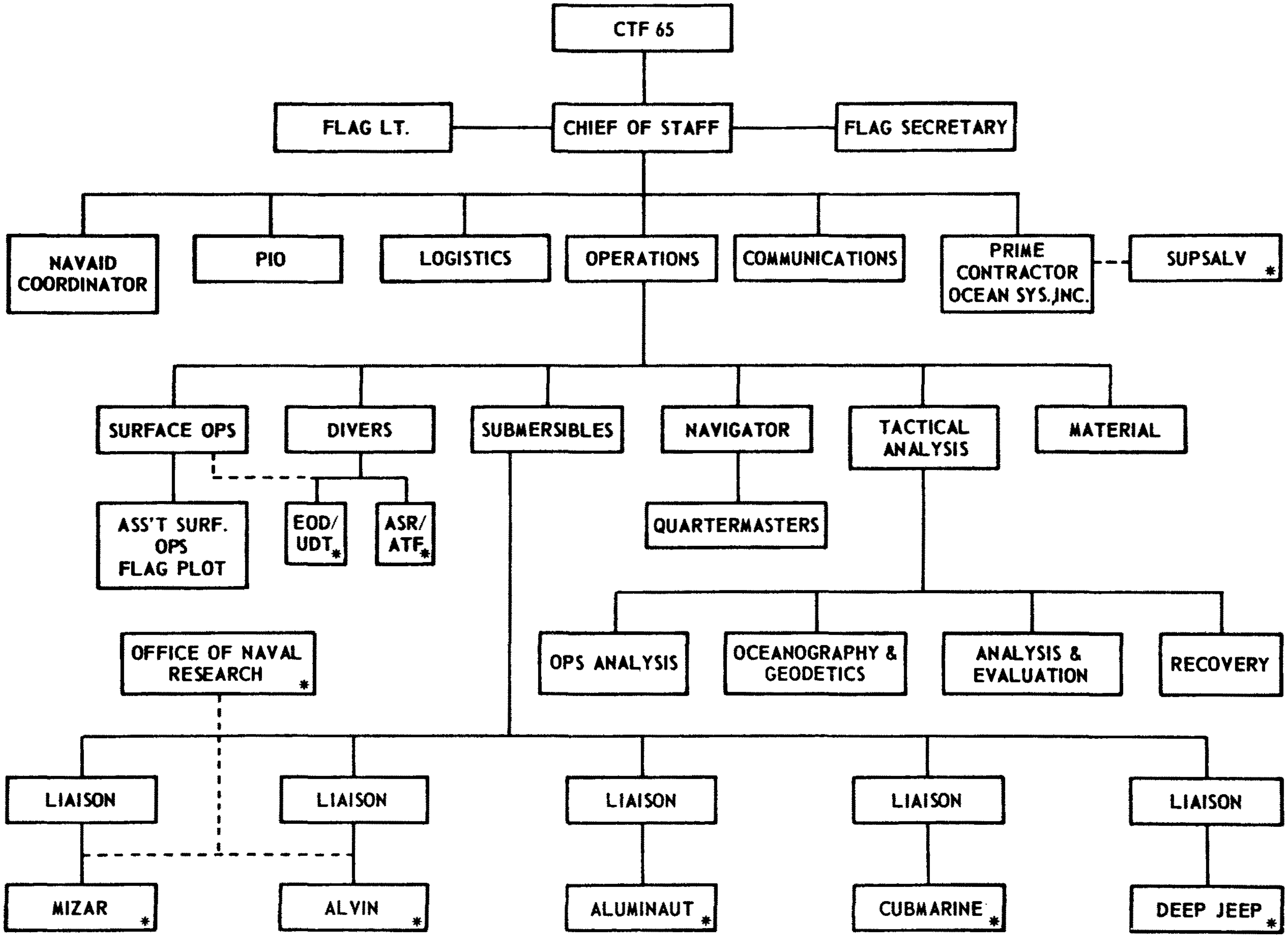


Figure 3-3 Modified Chain of Command



* Indicates a non-staff organization.

Figure 3-4 CTF Staff Organization

by the middle of February. It is of note that all four of the naval officers were qualified submariners, an appropriate selection in light of the fact that CTF-65 was an aviator and not experienced in matters pertaining to search for and recovery of objects on the ocean's floor. With the addition of these seven personnel, CTF-65 at last had an adequate functional staff. The director of the group was assigned as TF-65 operations officer on the staff, thus providing the submarine experience heretofore missing from the task force organization.

To organize the TAG, CNO drew upon men who were not only experts in their own right, but those who also headed the organizations most intimately connected with recovery at sea. These groups from within the Naval establishment were augmented by consultants from various civilian companies having experience in this field. Table 3-1 lists the members of the TAG and their respective positions within the Naval establishment or civilian community.

TABLE 3-1

TECHNICAL ADVISORY GROUP

Established by the Chief of Naval Operations in response to a request of the Secretary of the Navy. Met formally for the first time on 24 January 1966, in Washington, D.C.

Members

Rear Admiral L. V. Swanson	Chairman
Rear Admiral O. D. Waters	Oceanographer of the Navy
Captain E. J. Snyder, Jr.	Special Assistant to the Assistant Secretary of the Navy (R&D)
Captain W. F. Searle, Jr.	Supervisory of Salvage, U.S. Navy
Doctor John P. Craven	Chief Scientist, Deep Submergence Systems Project
Rear Admiral (retired) E. C. Stephan	former chairman Deep Submergence Systems Review Group

Various other Navy, Air Force, and commercial representatives on an as-needed basis

Although not formally depicted on the organization charts, official liaison was established with a small Spanish Naval detachment in Aguilas. It was this group which ordered the available vessels in the area to proceed and assist immediately after the accident. They, too, were tasked with supporting TF-65 in maintaining the integrity of the search area and search operations. On one occasion, when a French salvage ship showed up in the middle of the Task Force, the Spanish authorities were asked to use their influence in removing the unwanted guest from the area of operations. The French ship complied. The Spanish Naval effort was very successful.

COMMAND AND CONTROL:

Although it is apparent from the discussion in this section, one point deserves emphasis. TF-65 was a diverse assemblage of ships, naval personnel, and civilian specialists. As with any special purpose group brought together for a specific purpose, command and control assumes significant importance. The problems of command are also magnified by any situation where political implications of international importance exist, as they did at Palomares.

Published accounts of TF-65 operations have cited friction between some military and civilian personnel as being detrimental to its mission. This friction is described as resulting mainly from differences of opinion on the conduct of search operations, the importance of various findings and the like. What these accounts fail to portray is the immensity of the problem of locating the bomb, if it could be located at all. This operation met and overcame problems never before encountered. TF-65 operated in a difficult environment and it succeeded in its mission. That should be, and is, the principle item to lead any report of its activities. That is the tribute deserved and shared by the officers, seamen, and attached specialists of the command.

Communications, a vital component of Command and Control, were initially nonexistent in the Palomares area. Even ashore, considerable time and effort were required to reach a telephone and then there was no guarantee that the call could be completed successfully. No rapid means of classified communications were available until adequate radio equipment and the required power source could be shipped in and installed. For the sea operations, there were two primary communications channels required. One was local in nature and served the immediate operational requirements of the Task Force and its support units. This system was unsatisfactory on many occasions. Insufficient frequencies were available to handle both administrative and tactical traffic because many ships were auxiliaries or Military Sea Transportation Service ships who were often limited in communications, personnel, and equipment. Included in the limited category was the ship-to-submersible circuit. While communications to the ALVIN and ALUMINAUT via the UQC-1 systems were reliable, the range capability was limited and some interference was experienced when the two submersibles were operating in contiguous areas. Even greater difficulty was encountered by the CUBMARINE and its control vessel, usually a minesweep (MSO). Desired course information was generated from sonar contact with the target and the submersible. The course to steer was then relayed to the open bridge by sound powered phone, thence to the tending motor whale boat by walkie talkie radio and finally to CUBMARINE by the Aqua Sonics underwater telephone. Is it any wonder then, that the resulting orders and information were often lacking in clarity and completeness.

The second communications channel of import was the one providing a reliable link between the CTF-65 and his immediate senior in the chain of command. This channel was not effectively established until the arrival of the cruiser, USS BOSTON (CAG-1) (Fig. 3-5), on January 1966. It was through this ship's capabilities that CTF-65 was able to request assistance and report progress to the CNO and the TAG in Washington, D.C.

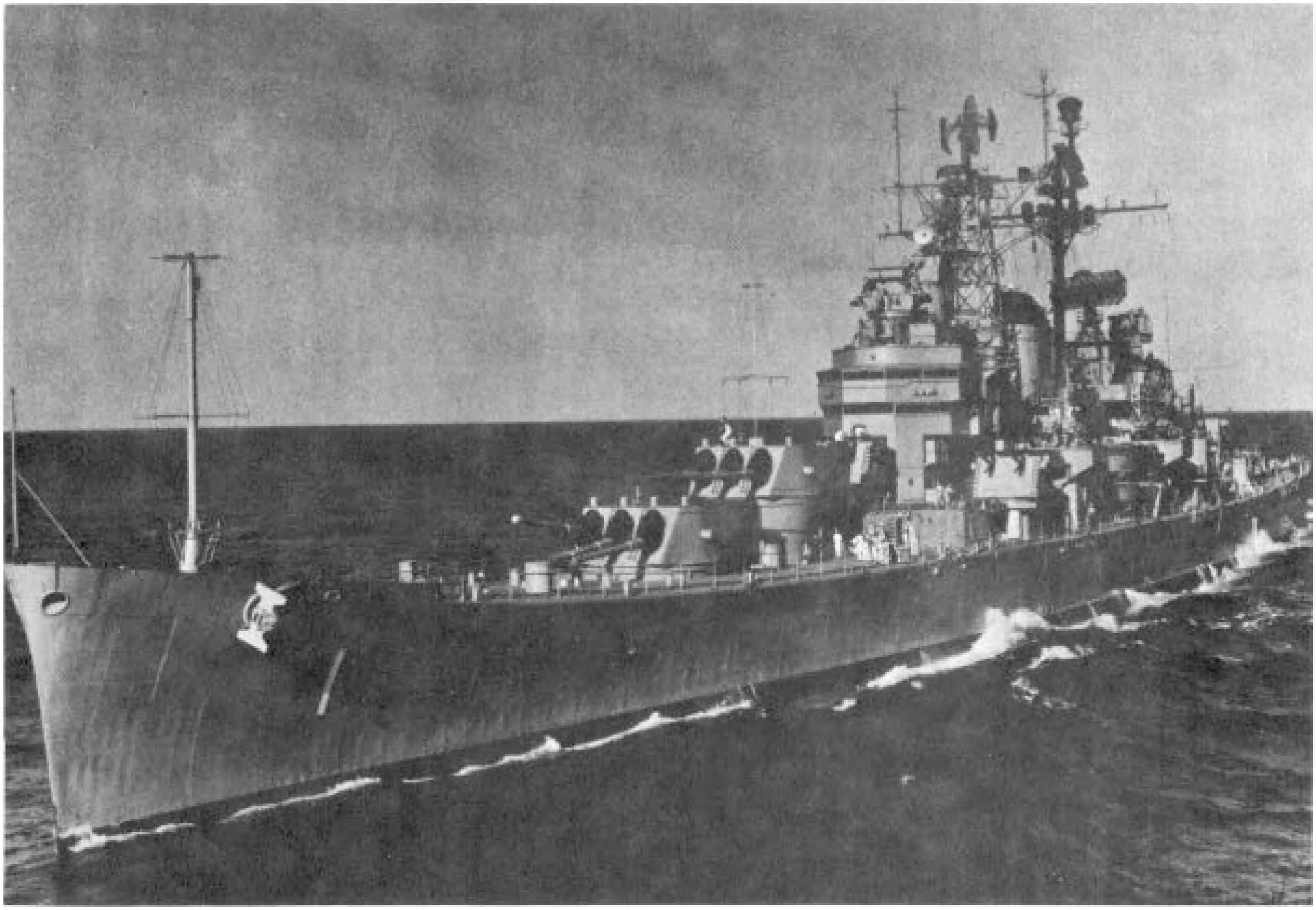


Figure 3-5 USS BOSTON

OPERATIONAL REQUIREMENTS:

Shipping assets required by operations generated in AIRCRAFT SALVOPS MED grew from one fleet tug to a virtual armada of Naval and commercial vessels. The urgency of the situation dictated that the initial contingent of TF-65 initiate immediate action within its capability. Little more than the basic facts concerning the aircraft accident were available to those early participants. The information available to the CTF, upon his arrival at Camp Wilson on 24 January, consisted only of a rough estimate of the actual position of the collision, some guesses concerning the sequence of events following the break-up of the B-52, existing meteorological phenomena, and the location of the surviving crew members and assorted aircraft debris.

The sighting of an object suspended from a large white parachute, its position, and significance to the overall search effort have been matters of uncertainty even to the time of this writing. On 21 January, prior to CTF-65 arrival, several actions had taken place that were to impact on the entire search effort.

The first two ships to arrive with any search capability, the Minesweepers, USS SAGACITY (MSO-469) (Fig. 3-6), and USS PINNACLE (MSO-462) commenced a random search in the area using their hull-mounted search sonar (UQS-1). On the following day, the splash-down point of the large white parachute was confirmed when the Spanish fisherman, Francisco Simo' Orts, who had been closest to the position in question on the day of the accident, was taken aboard the USS PINNACLE. Senor Simo' Orts positioned the ship by seaman's eye. A sonar search of the area resulted in two promising sonar contacts at a depth of 2040 feet. These contacts were reconfirmed by leaving the area and again asking the fisherman to position the ship over the splash-down point. Again the sonar contacts were obtained. Unfortunately, nothing further could be done toward identifying these contacts until a much later date. A confirmation of the splash-down point was received from two other sources; one, a Spanish pharmacist in the vicinity of Garrucha and the other, his assistant located approximately 1 to 1 1/2 miles north. Both men observed the splash-down of the white parachute and provided bearings to the position. These bearings all passed through the search area finally designated as Alpha I. It is rather ironic, if true, that Simo' Orts attempted to pull on board his boat a very heavy object attached to a parachute. Unable to raise the weight and after having dented his boat in the attempt, he released the parachute and its hidden weight and watched it sink into the depths. How different the next 81 days might have been, had he towed the object into shallow water. (This incident was not confirmed in official testimony.)

Armed with a meager amount of information of questionable accuracy, CTF-65 set about establishing an operational plan. Certain aspects of the task were determined, followed by action to provide the ships, personnel, and equipment needed to meet the known requirements.*

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* Note - The following functions are not in themselves unique, but categorize the primary purpose of the units as assigned. At various times some of the ships served in secondary and sometimes dual capacities as the need arose.

Figure 3-6 USS SAGACITY

Security:

To a world in the throes of a cold war under the threat of nuclear conflict, security measures were high on the list of tasks assigned to TF-65. Several areas were considered important. Area surveillance was conducted by various sea and air units, according to their availability. Their mission was to insure the integrity of the operational area and to maintain continuous surface and subsurface surveillance of the seaward approaches. Surface units were selected from the ships which were assigned to TF-65 and in the area. Air surveillance was provided by aircraft from nearby land bases. Perhaps the most significant surveillance/security operation was that of tracking the Soviet Elint Trawler "LOTSMAN" which observed AIRCRAFT SALVOPS MED for a period of 12 days. Area security was further enhanced by Spanish patrol craft who assisted in keeping the local fishing fleet from interfering with the search and recovery operations.

In addition to the physical security, these units provided command facilities for CTF-65 and his staff, serving as flagship and insuring secure communications to assigned units as well as up through the chain of command. In general, a cruiser, or destroyer was assigned these duties.

Search:

A random search effort began upon the arrival of a search capability. However, to continue such operations would have been a waste of time, men, machines, and money. Random search over such a large area, approximately 130 square miles, would have been inefficient and provided no measure of search effectiveness. CTF-65 immediately designated specific search areas and assigned a priority to each, commensurate with the degree of reliability of the known facts and sightings. The methods and evidence used to finally pinpoint the positions of the search areas varied widely. Of greatest concern, was the selection of the center of area Alpha I. This, in fact, played an important roll in the litigation of the Simo' Orts claim against the U.S. Government for services rendered. A number of factors were considered in determining the search areas, some having greater impact than others on any specific area. In the main, these factors were:

Track of the B-52

Wind direction and velocity from aircraft altitude to thé surface

Debris pattern ashore and near the beach

Survivor splash-down points

Air Force computer studies based on the above

Sonar contacts

Visual sightings from personnel on shore

The observations of the fisherman Sino Orts

Area Charlie coordinates were selected by reference to the Air Force computer studies and survivor splash points. Area Bravo was based on the Air Force computer studies. Area Alpha II was selected mainly as an extension of the debris pattern on shore. Finally, and the most auspicious was the selection of Alpha I by CTF-65. This selection was primarily based on the mean of eleven Ocean Bottom Scanning Sonar (OBSS) and UQS-1 contacts which were accorded high credibility because of the statements and plotted evidence from the Spanish fisherman Simo' Orts and the pharmacist and his assistant in Garrucha. These area selections were not finalized until 17 February at which time some 150 contacts had been logged and many processed. Figure 3-7 illustrates these areas with their underlying bathymetric contours. Priorities finally assigned followed in alphanumerical order. These areas were designated by latitude and longitude in reference to the then available navigational charts of the area. These charts were not very accurate.

The navigational aids consisted of radar for range and bearing fixes, consolan, radio beacons, visual landmarks and Loran-C. Radar, consolan and radio beacons are not accurate enough for high order positioning. Visual aids were not on a common datum and in proper relationship to the search area; therefore, they were not useful in the search. Loran-C would not have been suitable due to the distance to the transmitting stations, resulting in weak signals being available in the search area. The only medium or large-scale chart covering the Palomares area in the chart allowance for ships in the Mediterranean Sea is H.O. 3930, scale 1:233640. This chart was compiled in October 1935 from old Spanish charts and was revised in October 1966. The chart carries the note: "Some features on this chart may be displaced as much as one-half mile from their true position." It was found that this was the rule rather than the exception. One more chart (identified as SPN. 108) existed covering the search area and it was reprinted by the Navy Oceanographic Office (NAVOCEANO) in January 1966 from a Spanish chart compiled in June 1960, from latest Spanish surveys. Insets on this chart are a chartlet of Palomares and Villaricos and a chartlet of Garrucha. Both of these chartlets are to a 1:25,000 scale, but neither the main chart nor the chartlets contain sufficient sounding data or landmarks to be of value to AIRCRAFT SALVOPS MED.

In order to fulfill the requirement for a high accuracy, medium range, electronic positioning system, a DECCA Hi-Fix navigation net was installed by 6 February. The DECCA Hi-Fix net, as installed, could only be used for relative positioning. This was remedied by employing a NAVOCEANO geodetic survey team to fix the system transmitter locations on a common datum. A LORAC support team from SERVRON 8 was ordered into the area to operate the shore stations since a considerable amount of equipment and personnel were required to maintain a DECCA Net on a 24-hour basis. Figure 3-8 illustrates the net of the DECCA Hi-Fix System as installed.

In addition to a high accuracy electronic positioning system, more accurate bathymetric information was required. This was accomplished concurrently with the establishment of the operational DECCA system. The initial bathymetric chart was delivered to CTF-65 on 29 January 1966, and the final bathymetric survey was completed 26 February by the USNS DUTTON. The resulting bathymetric information is depicted in Figure 3-7.

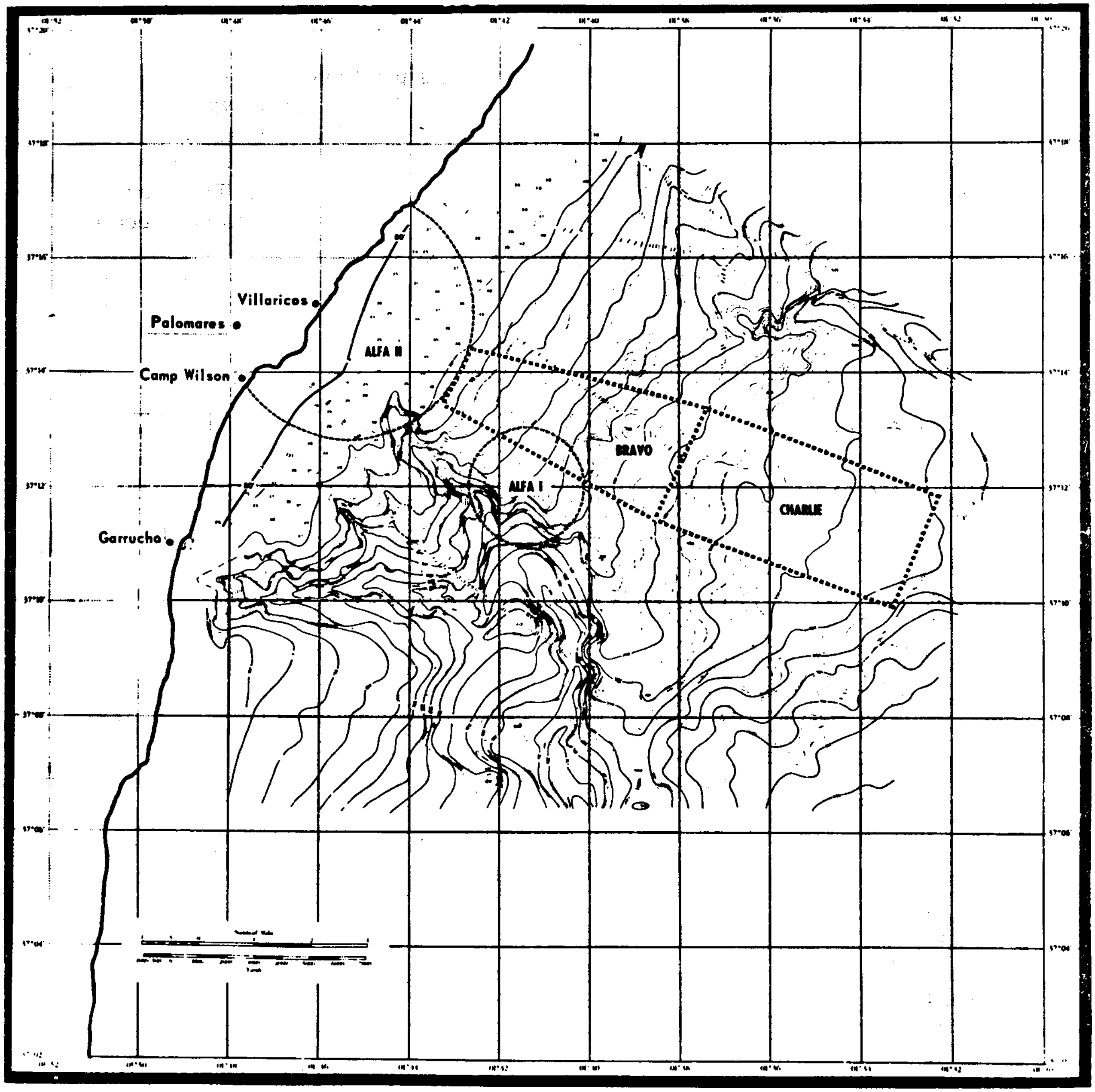


Figure 3-7 Underwater Contours

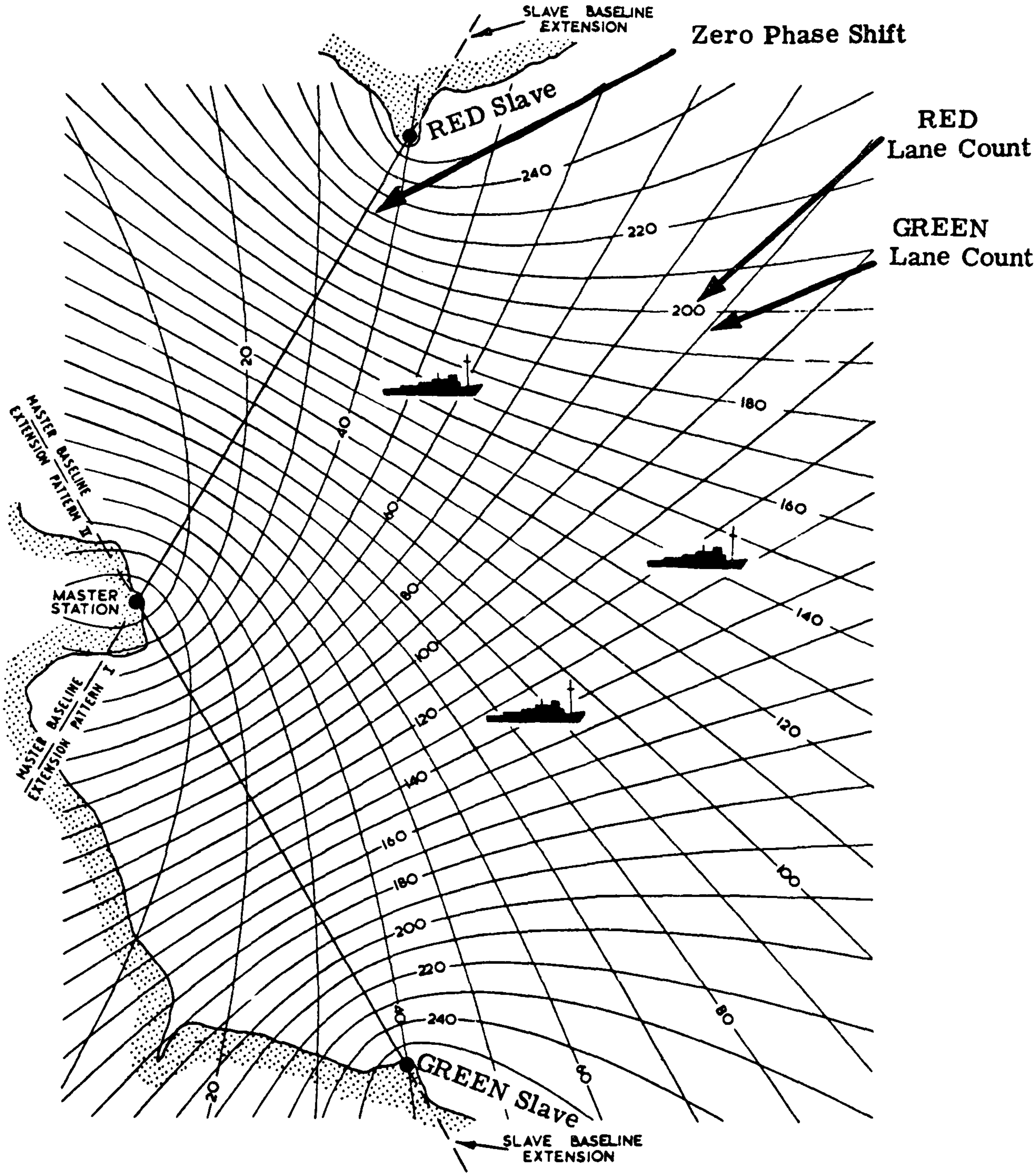


Figure 3-8 DECCA Hi-Fix System

Having determined the areas to be searched, it was then necessary to assign the available search assets so that their capabilities and limitations matched the requirements of the areas to be covered. It was soon recognized that the basic search forces required augmentation for adequate inshore coverage, resulting in a request for additional swimmers and divers. Figure 3-9 demonstrates how the various equipments were utilized to cover the depth requirements.

Basic to the search philosophy in areas searched by electronic sound systems, was the necessity to somehow verify each contact. A team concept was developed whereby units were organized into teams so that their individual capabilities complemented each other. However, staff requirements, weather restrictions and normal scheduling problems made it necessary that team assignments remain flexible.

The search plan which evolved was split into two components. One component was the inshore search area from the water's edge out to the 80-foot depth contour line. This area was separated into block areas of a size that could be covered each day with a complete visual search, for 100 percent coverage, by the divers available. The second component, the area outside the 80-foot depth required more sophisticated methods. Since it was not practical to utilize divers for full coverage at the deeper depths, such acoustic equipments as the Sea Scanner, UQS-1, or the Ocean Bottom Scanning Sonar (OBSS) were put into service. In the case of the Sea Scanner, divers were an integral part of the search team, but not with the other systems and so identification and recovery teams were needed to follow-up the contacts.

There were drawbacks to the follow-up method. For instance:

The lack of positive identification during the time the sonar operator held the contact on his scope, deprived the operator of valuable signal interpretation which would be available if operators had data from known objects on which to base their evaluations of the nature of contacts obtained.

Methods of marking the contact, usually a float and anchor, were not only inaccurate at the time buoys were planted, but the buoys were subject to displacement during inclement sea conditions. This marking system was also limited by depth and bottom contour.

Acoustic systems were hampered in three ways:

1. Rough bottom configuration as existed in Alpha I (Fig. 3-7) causes unwanted reflections and reverberations of sound signals.

2. Absence of a baseline target signature and precise knowledge of the bomb dimensions influenced the sonar operators' contact descriptions.

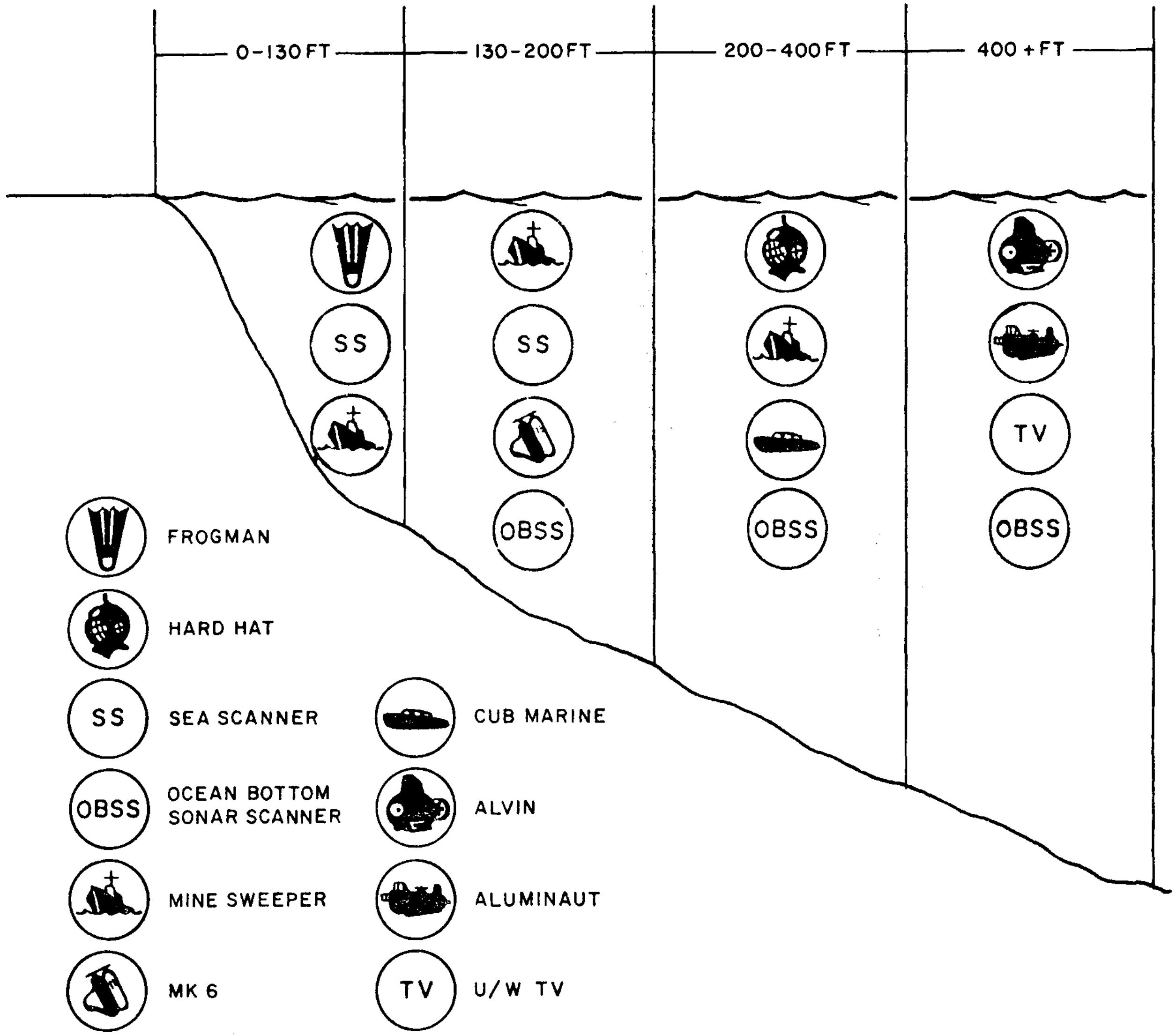


Figure 3-9 Search Methods at Various Depths

3. Inaccuracies in navigation, which prevented return to the same precise positions, led to duplicate contacts and frequent inability to relocate targets previously detected.

Since failure to locate the missing nuclear weapon was a definite possibility, CNO had directed that sufficient records be generated to provide proof of the effort applied and the search effectiveness of that effort. The method devised utilized a grid overlay of the search area (Fig. 3-10). This grid consisted of lettered 2 x 4 mile rectangles oriented with the long dimension parallel to the general contour of the coastline. Each rectangle was subdivided into numbered 1000 x 1000 yard squares which were the units used in making search assignments. The degree of coverage of each of these squares was used to determine search effectiveness.

Two aspects of equipment effectiveness were weighed and caused a variation in the general search plans. The relative mobility of the team using the CUBMARINE dictated that it be assigned to areas of high contact density in order to identify contacts at a higher rate. Because the rate of contact acquisition by acoustic systems far exceeded other methods, the CUBMARINE spent most of its operational time identifying these contacts in depths beyond the capability of the divers.

The deep water region in and about Alpha I was treated as a separate case. Here the ALVIN and ALUMINAUT were assigned visual searches in additon to contact investigation. This was due to navigational limitations which prevented the submersibles from relocating sonar contacts obtained by other means, and the generally unreliable nature of acoustic search in this more rugged bottom terrain. The USNS MIZAR possessed a deep photosearch capability and, therefore, was assigned to search operations in the deep area when not being utilized as a control ship for submersibles.

SEARCH SUMMARY:

The selection of equipment for use in the various search areas was based on equipment characteristics, overall search results and the time required to cover a given area, and the ability of the available equipments to cope with the environments, in the defined search areas. The prime source of contact data was sonar equipment. It detected items of all sizes and composition, from rocks and pebbles to large sections of the aircraft wings. All contacts had to be identified either visually or photographically since even the sonars with the highest-definition (about 6 inches for the OBSS) were unable to provide sufficient data for acoustic identification. This dictated that all contacts be revisited and either sighted or photographed. This requirement placed a major burden on the navigation systems available. In shallow water, over smooth terrain, results were satisfactory because ranges were short and inherent equipment errors negligible. However, in water over 200 feet in depth, artificial light was required and range and bearing errors became significant regardless of the terrain. The rough terrain in the southern half of Alpha I made acoustic systems totally ineffective. Towed search vehicles experienced the same difficulties. Inaccuracies in position increased with depth. Inability to detect the irregularity of the bottom in time to adjust the depth of the tow causes several collisions with the bottom which damaged sensors. The towing duties were mainly assigned to the minesweepers,

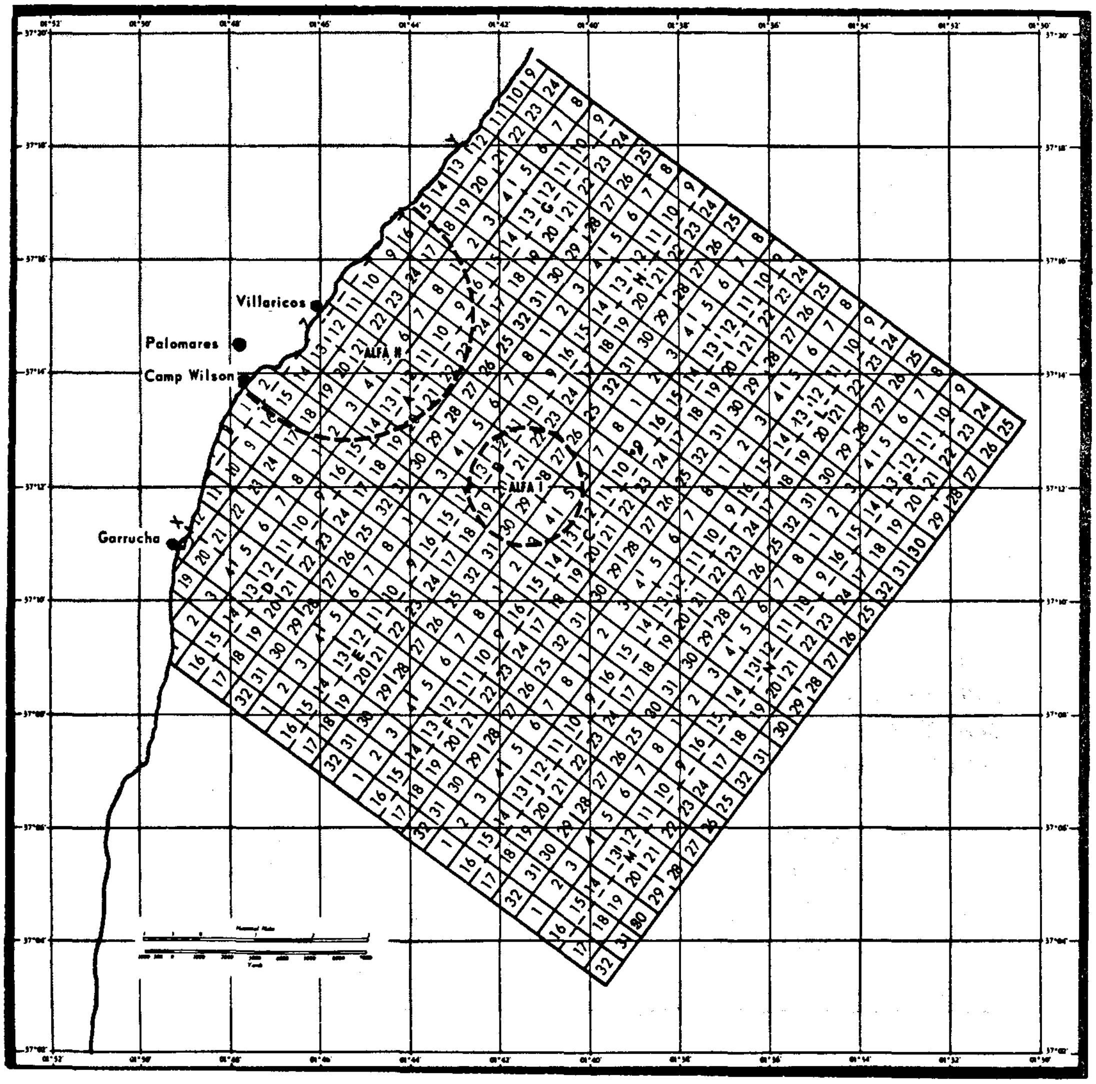


Figure 3-10 Search Grid Overlay

which in spite of the resemblance of towed search equipment to minesweeping gear, experienced two additional limitations and the loss of three towed vehicles. A difficult ship handling problem existed at the 1-2 knot tow speed of the OBSS making the maintenance of a search track impossible in any increased wind or sea conditions, and the physical requirements of recovery dictated diver assistance to shift the tow rig from astern to a midships boom for hoisting aboard, a relatively difficult and dangerous task in high sea states (Fig. 3-11).

Use of the underwater TV system (Fig. 3-12) required even more stringent operating parameters. It could not be towed, and so necessitated extremely accurate ship positioning for either search or contact identification. When a multipoint moor was feasible, search or identification could be conducted by a trial and error dipping procedure until the area accessible from that moor was covered. When a moor was not feasible, the operation was practically impossible.

Forty-two days after the accident over Palomares, and on the tenth dive by ALVIN, a target was discovered in the vicinity of the place where Simo' Orts reported seeing a weapon descend. It was approximately 400 feet long rather than the expected 10 feet and is explained in the following ways.

After water entry, the nuclear weapon, still suspended from its parachute, descended to a depth of 355 fathoms riding the prevailing currents. It touched down on the rim of an underwater ridge and was apparently dragged over the edge by the current forces on the chute, subsequently slid into the deep submarine canyon depicted in Figure 3-13. From here it continued its descent to a depth of 425 fathoms, leaving a smooth furrow. It was this furrow, shown in Figure 3-14, that was first discovered by ALVIN on 1 March while conducting contour searches at constant depth levels. Close to the end of her submerged endurance, ALVIN attempted to follow the furrow down the steep slope but was unable to keep it in sight. Nearing the end of her battery life, she was forced to surface. Eight search missions in the same area and 12 days later, ALVIN relocated the furrow, but again did not reach the end of the track prior to being forced to surface due to battery exhaustion. The next day was spent in maintenance and finally on 15 March ALVIN successfully backed down the furrow to discover a parachute enshrouded object (Fig. 3-15) at a depth of 2550 feet lying on a 70 degree slope. The object was designated contact #261. The first phase of the search was complete.

Phase II was to commence on 26 March following an abortive attempt to raise contact #261 on one line that was severed in the attempt, dropping the object. The second search effort presented many of the same problems and much anxiety for a period of 8 days, when on 2 April the object, still chute enshrouded, was located on a bearing of 210° T., a distance of 120 yards from its position on 15 March and now at a depth of 2800 feet, position 4 on Figure 3-13. The illusive weapon did not again evade the searchers of TF-65.

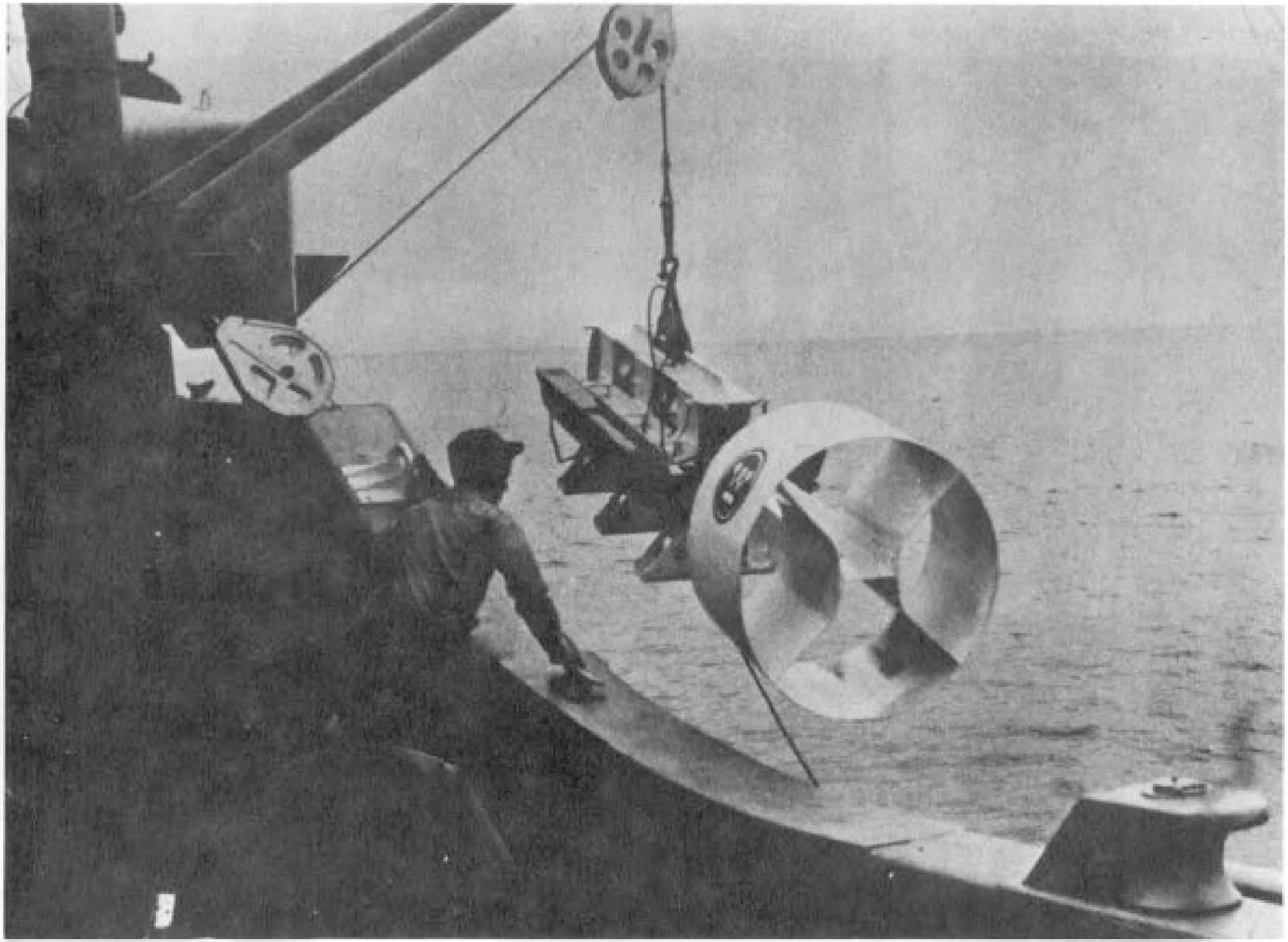


Figure 3-11   Waist Boom Hoisting Operation

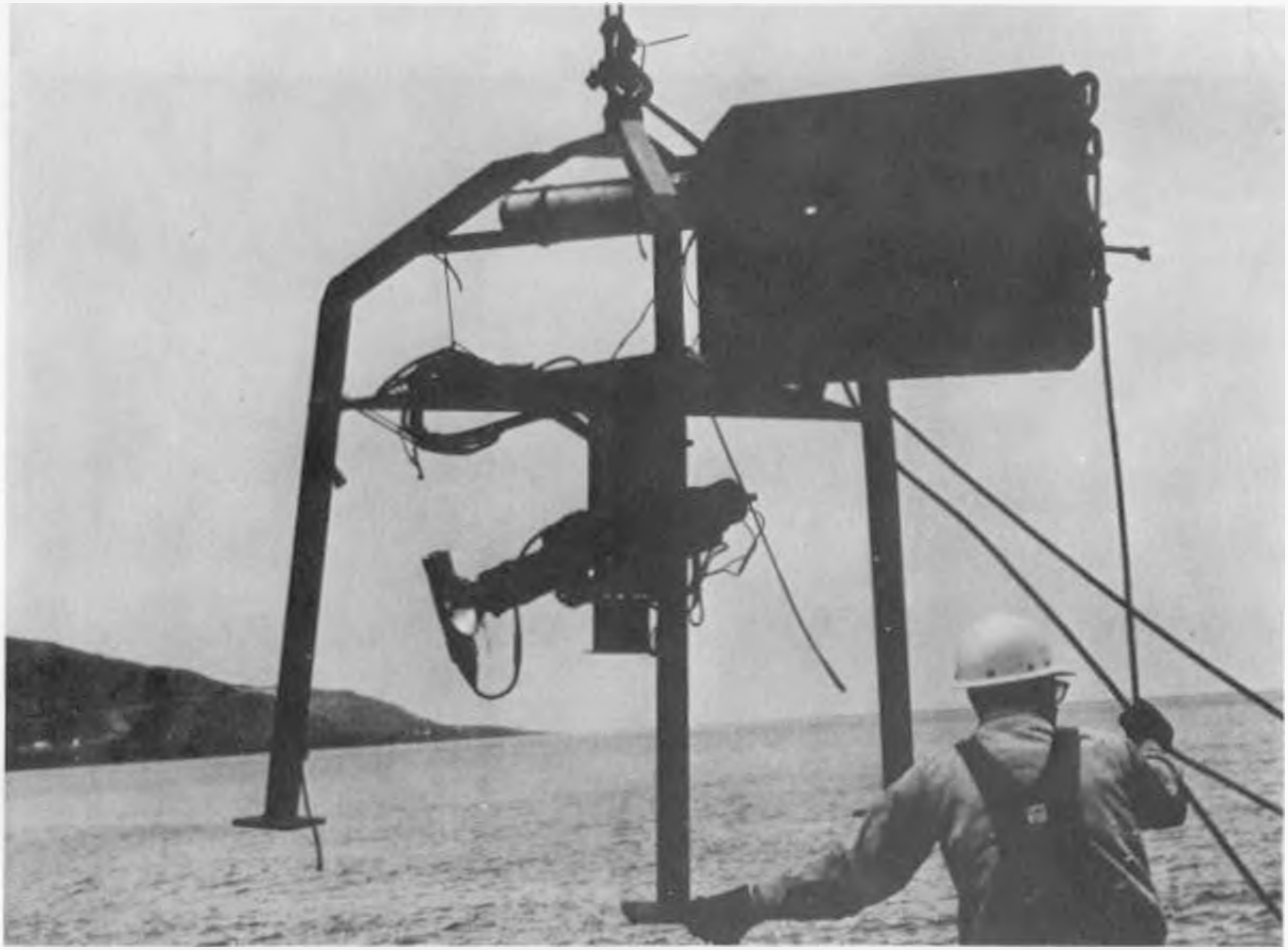


Figure 3-12   Underwater TV System

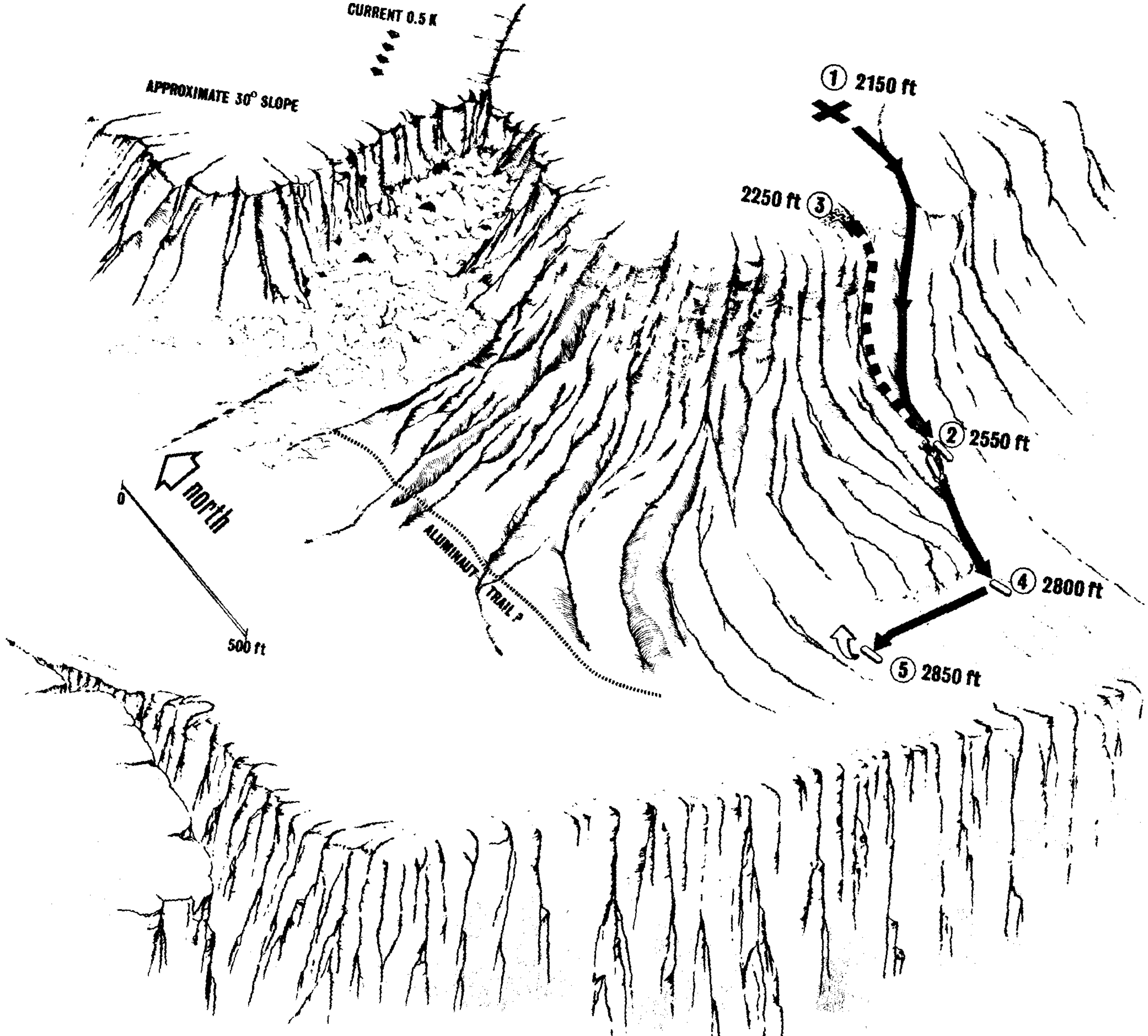


Figure 3-13 Underwater Canyon

Figure 3-14 Underwater Furrow

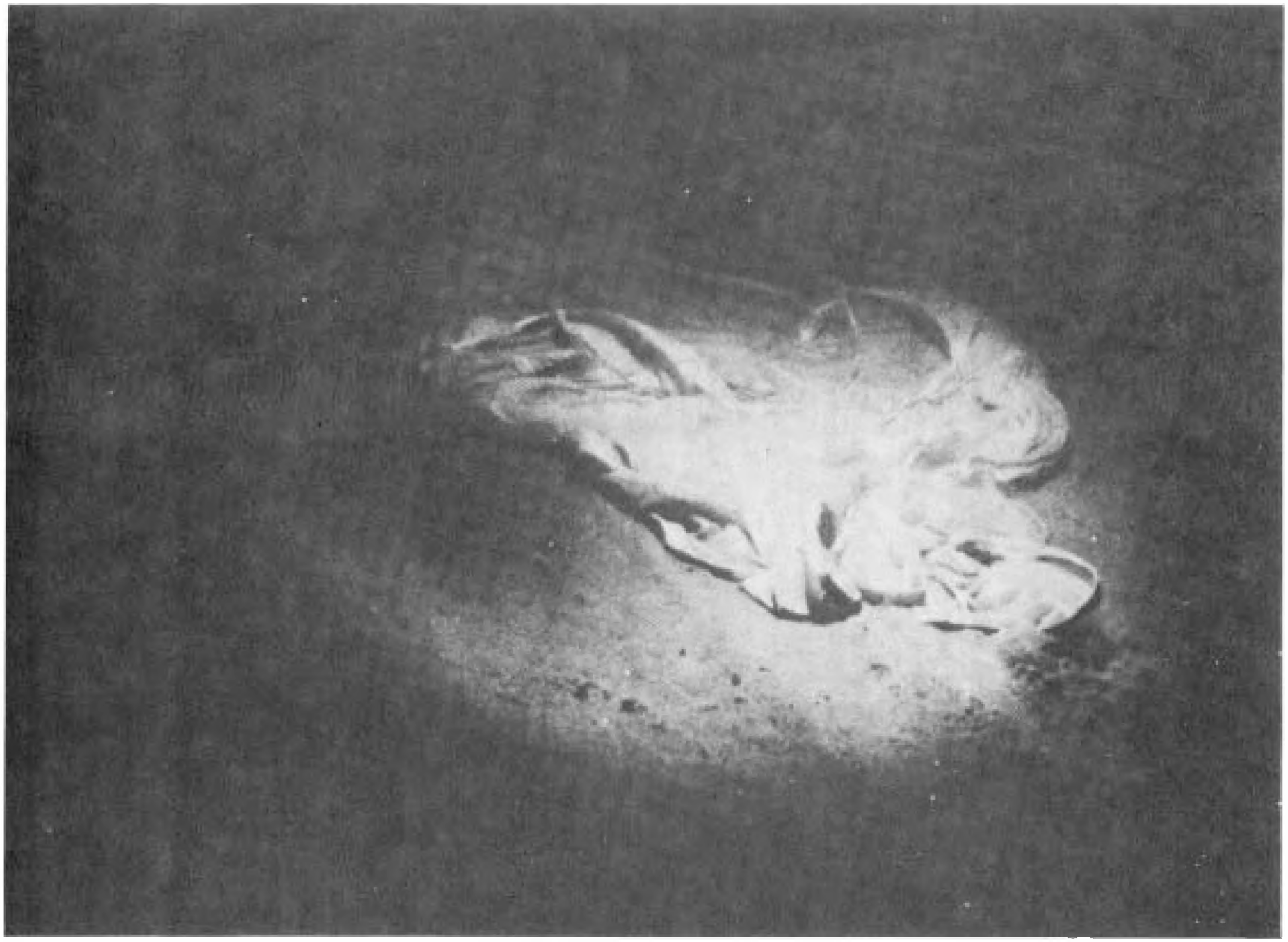


Figure 3-15   Parachute Enshrouded Weapon at 2550 feet

Identification:

While not entirely separable from search capabilities, certain systems possessed a more effective means of identification than others. And though there was overlap of these system capabilities, they can best be considered under three categories: divers, surface, and submersible.

Divers - During peak diver operations, approximately 125 Navy divers were assigned to the task force. Between 22 January and 7 March, they searched out, completely identified, and when size permitted, recovered 143 aircraft debris contacts in an area covering 3 square miles. It is obvious that from the standpoint of effectiveness and versatility, depth limitations considered, the swimmers and scuba divers were at the top of the list (Fig. 3-16).

Surface - Although providing mission versatility and an improvement in depth capability over free divers, the hard hat diver was less mobile, handicapped as he was by a tether to the attending surface vessel (Fig. 3-17). Additionally, his having to operate on the bottom caused silt clouds which restricted his visibility and usefulness. Also surface dependent were three other systems employed by TF-65. The underwater TV platform was limited in depth and extremely limited in mobility and search rate requiring a moored vessel for control.

Effectiveness was significantly enhanced by the Cable controlled Underwater Recovery Vehicle (CURV II) (Fig. 3-18). Although tethered to the mother ship, it combined sonar, closed circuit television, cameras and lighting with the ability to maneuver and recover relatively heavy objects from the ocean's floor to a depth of approximately 2900 feet. (Cable lengthened for AIRCRAFT SALVOPS MED (Fig. 3-19).

The third system, used by the USNS MIZAR was a towed sled on which a transponder, a battery, one to four cameras, a pinger and two strobe lights was mounted (Fig. 3-20). An underwater TV camera was available but not used on the sled. This system was primarily used for contact identification but was hampered by the 10-24 hour time lag required to process the film. This, time lag, inherent navigational error, and difficulty in maintaining a minimum fixed height above the bottom (as was the case with the OBSS), caused contact correlation errors not always reconcilable and sometimes resulted in damage through collision with the bottom.

Inherent in all of these unmanned systems was practically unlimited bottom time.

Submersible - This category of vehicle was by far the most expensive, the most versatile, the most dangerous, and certainly the most glamorous. Included within the category of Research and Development vehicles, they all were without proven operating procedures. AIRCRAFT SALVOPS MED, therefore, presented a fine opportunity to prove or disprove the system designs and to convince the world in general that future recovery operations would most certainly require comparable equipments. Excluding swimmers/divers (for depth limitations), the submersible pilots, backed up by external cameras, represented the most

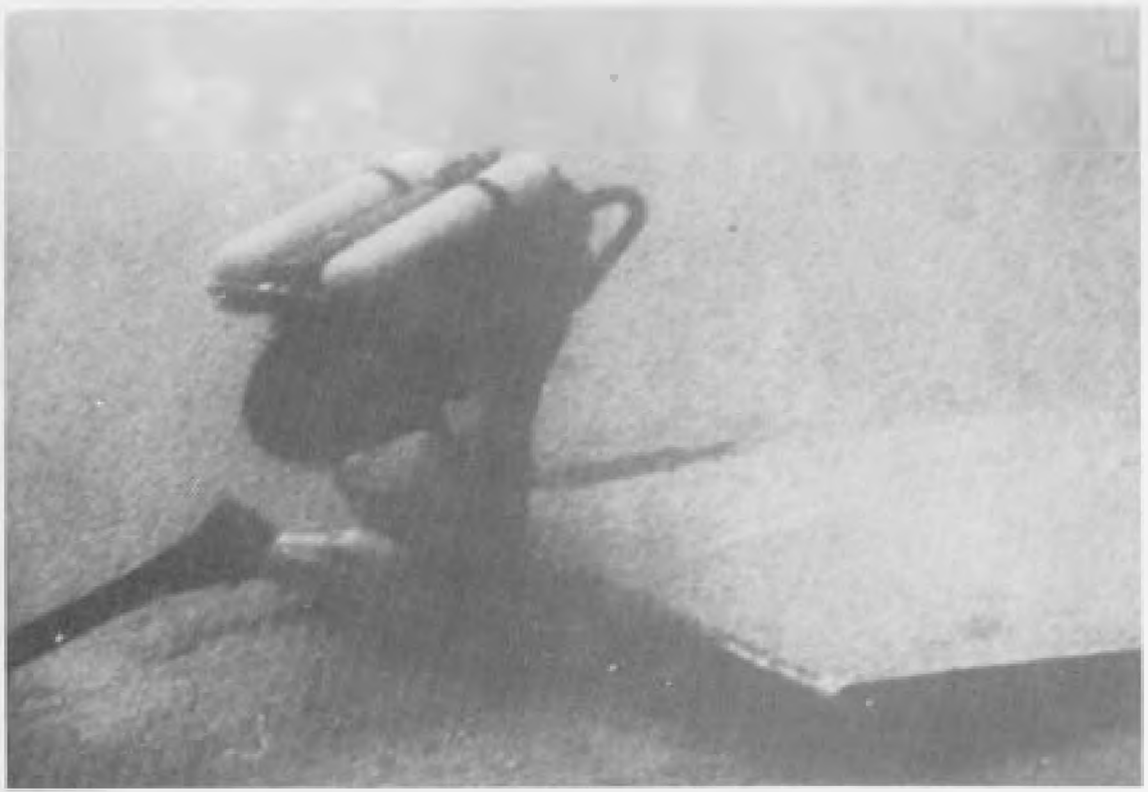


Figure 3-16 Scuba Diver

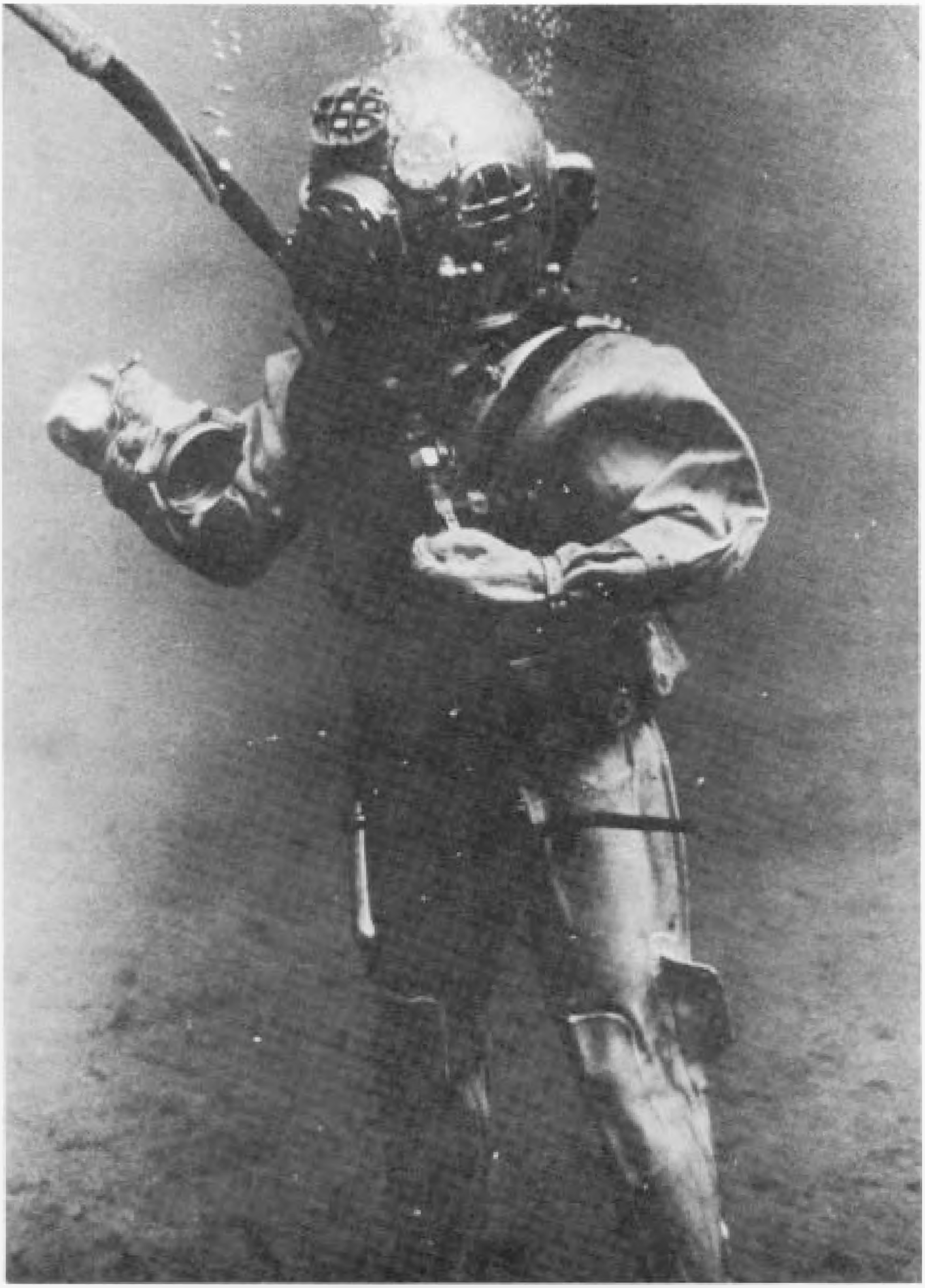


Figure 3-17 Hard-hat Diver

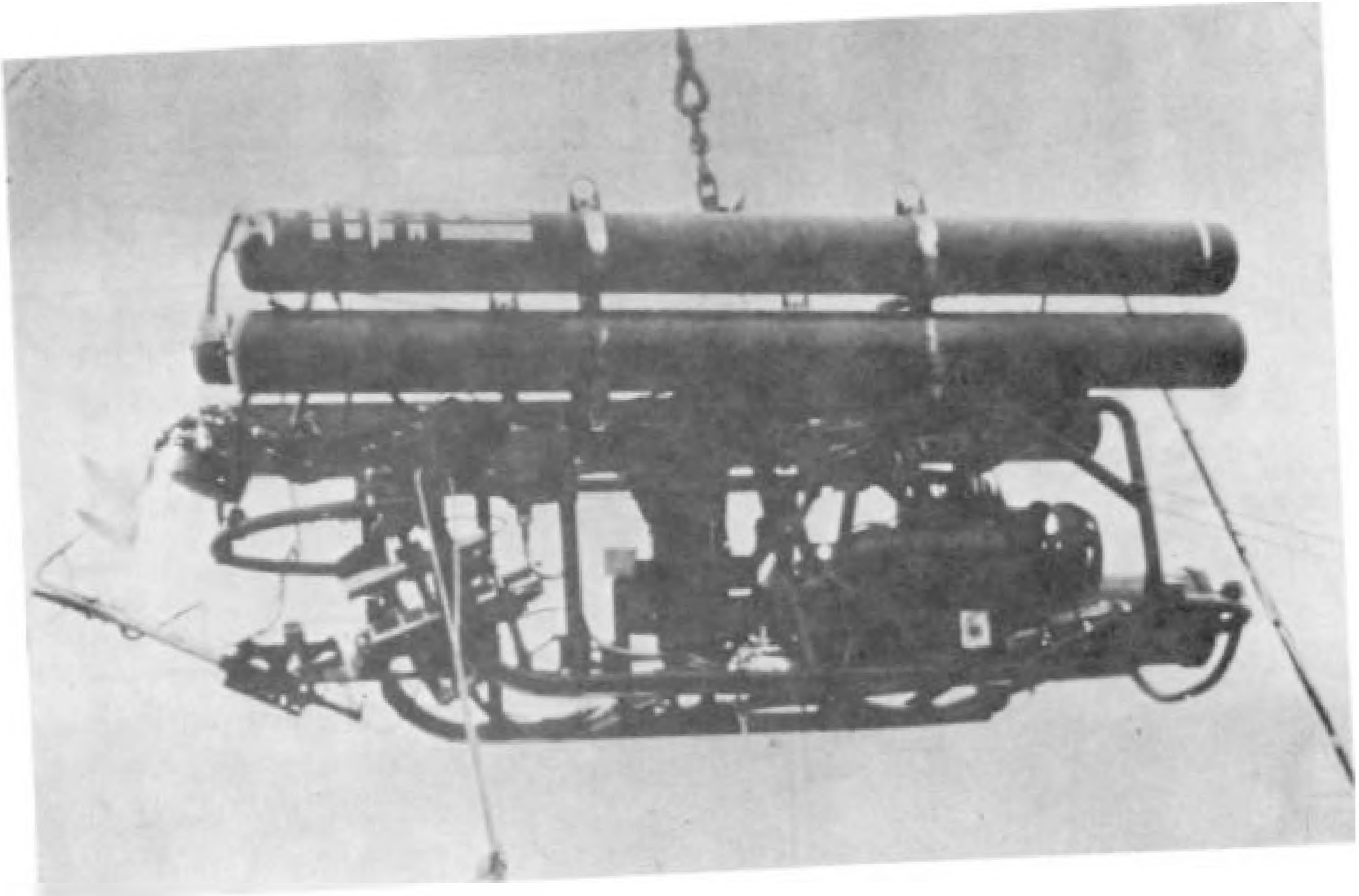


Figure 3-18 Underwater Recovery Vehicle (CURV II)

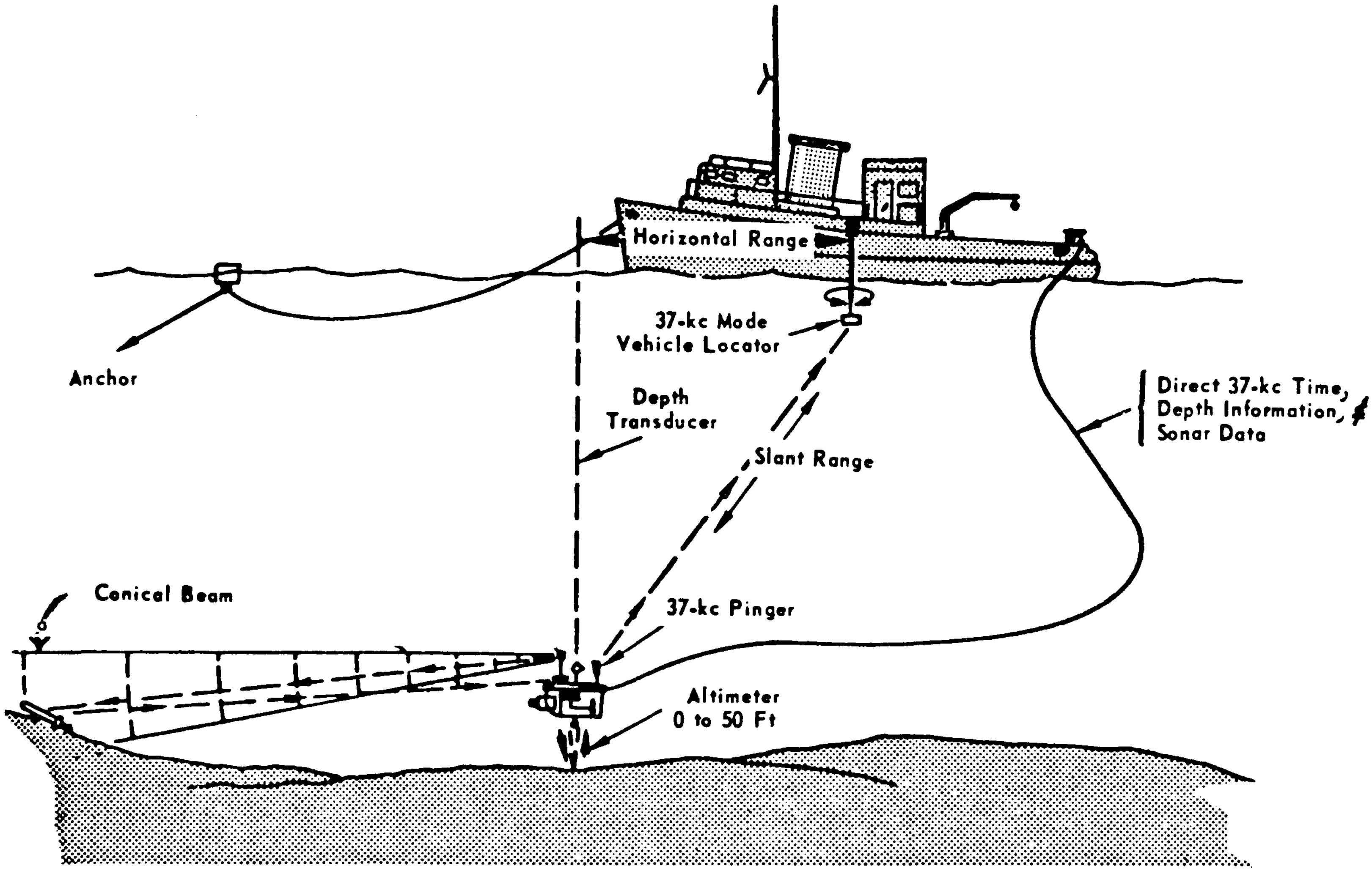


Figure 3-19 CURV II Recovery System

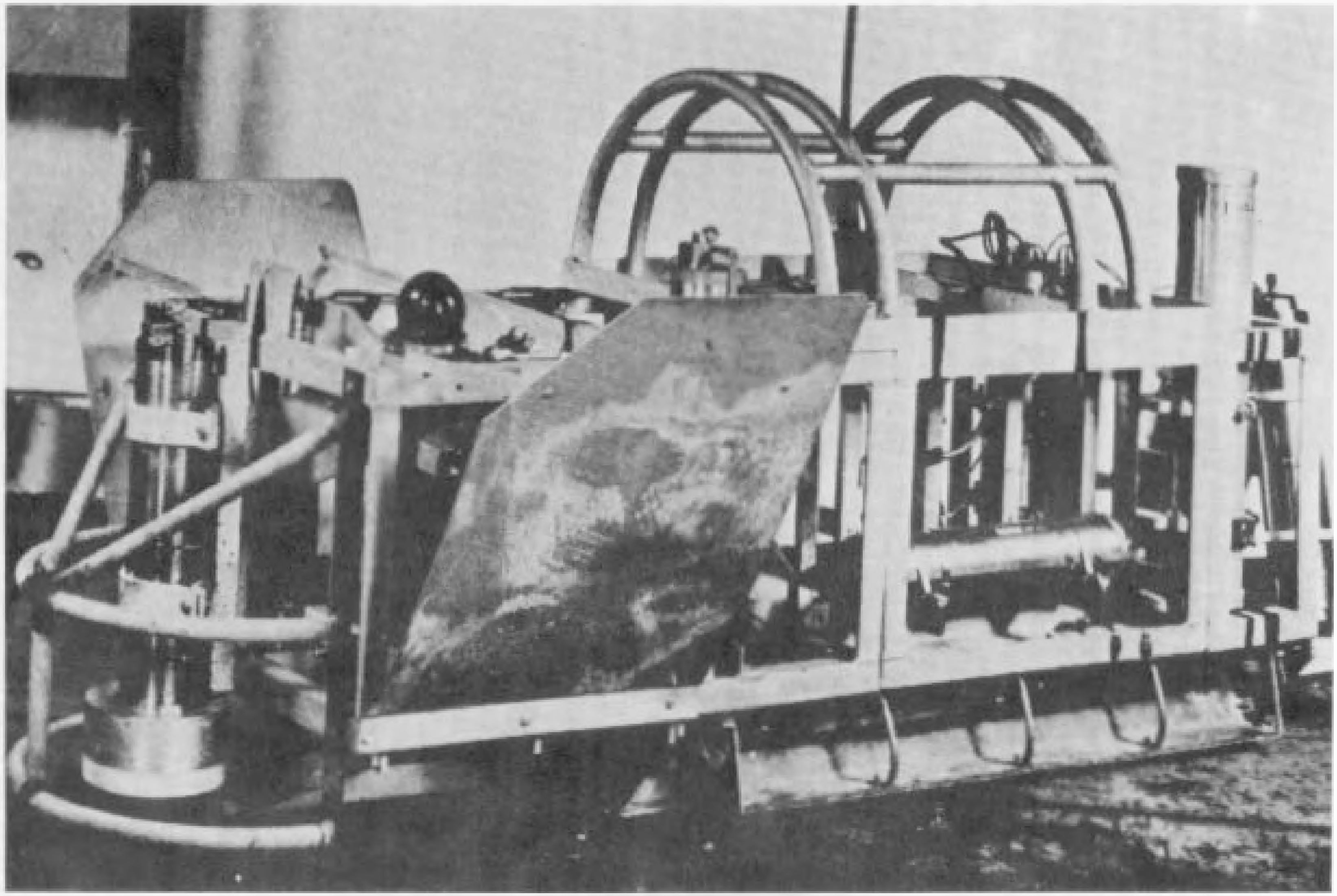


Figure 3-20 Sled Towed by USNS MIZAR

reliable method of contact identification. In spite of this reliability, other factors posed problems. Time on the bottom was limited by crew fatigue, endurance of the life support system and source of power for propulsion and illumination. These manned systems required many more hours maintenance time than their unmanned counterparts, and replacement parts were either nonexistent or difficult to obtain. A support organization or mothership was required, thus increasing the personnel requirement several fold. The vehicles were limited to relatively good weather operations by launch and recovery parameters and required a communications and navigation guide while submerged, since they were not equipped with a self-contained navigation system. Once submerged, they had to depend on the sonar derived steering instructions from the control ship to reach the general vicinity of the area in question. Then, unless previously visited terrain features were recognized, each dive was an adventure into a new world with only general guidance by underwater telephone. The working ability of each was limited by lack of leverage capability, making recovery of heavy objects difficult if not impossible. Additionally, the danger of entrapment was always a possibility with rescue prospects doubtful.

There were four such vehicles used during AIRCRAFT SALVOPS MED.

DEEP JEEP - Although first on the scene, DEEP JEEP was the first to be sent home. On station for only 8 days, it was able to come up with only one contact which was non-aircraft in nature. Disabled by a casualty to one of its electric propulsion motors that was beyond the capability of the Task Force to repair, it was flown back to its point of origin (Fig. 3-21). In summary, the DEEP JEEP was characterized as an inadequate search vehicle with poor mobility, inadequate power, narrow field of view, difficult handling characteristics on the surface, poor maintainability, poor external lighting, no sonar, and a depth limitation of 2000 feet.

CUBMARINE (PC-3B) - CUBMARINE by comparison, was extremely valuable. It spent 73 days on station and evaluated 44 contacts, 18 of which were aircraft debris. Although somewhat limited in endurance and depth capability, which reduced its search effectiveness, CUBMARINE exhibited high mobility, good maintenance, and good coverage. Because of its limited utility, the manipulator was not used. CUBMARINE was limited to 600-foot depth of operations (Fig. 3-22).

ALVIN - Next in size and best in maneuverability and adaptability to rugged terrain, ALVIN (Fig. 3-23) spent 72 days on station and evaluated six contacts, three of which originated from the B-52/KC-135 collision. When compared to the box score of CUBMARINE, ALVIN's contact results are misleading. Employed almost exclusively in deep water at the extreme limit of the predicted debris pattern, ALVINS's opportunity for contact in either the search or identification mode was several orders of magnitudes less than that of CUBMARINE. It is probable that ALVIN would have performed as well as CUBMARINE, given the same area assignment. In spite of the fact that ALVIN found the illusive nuclear weapon, both times, and received its share of the glory, it was not without its shortcomings. To counteract its effectiveness in rugged submarine canyons, the limited endurance, about 8 1/2 hours, made searching large flat areas inefficient. Construction and crew habitually accentuated crew

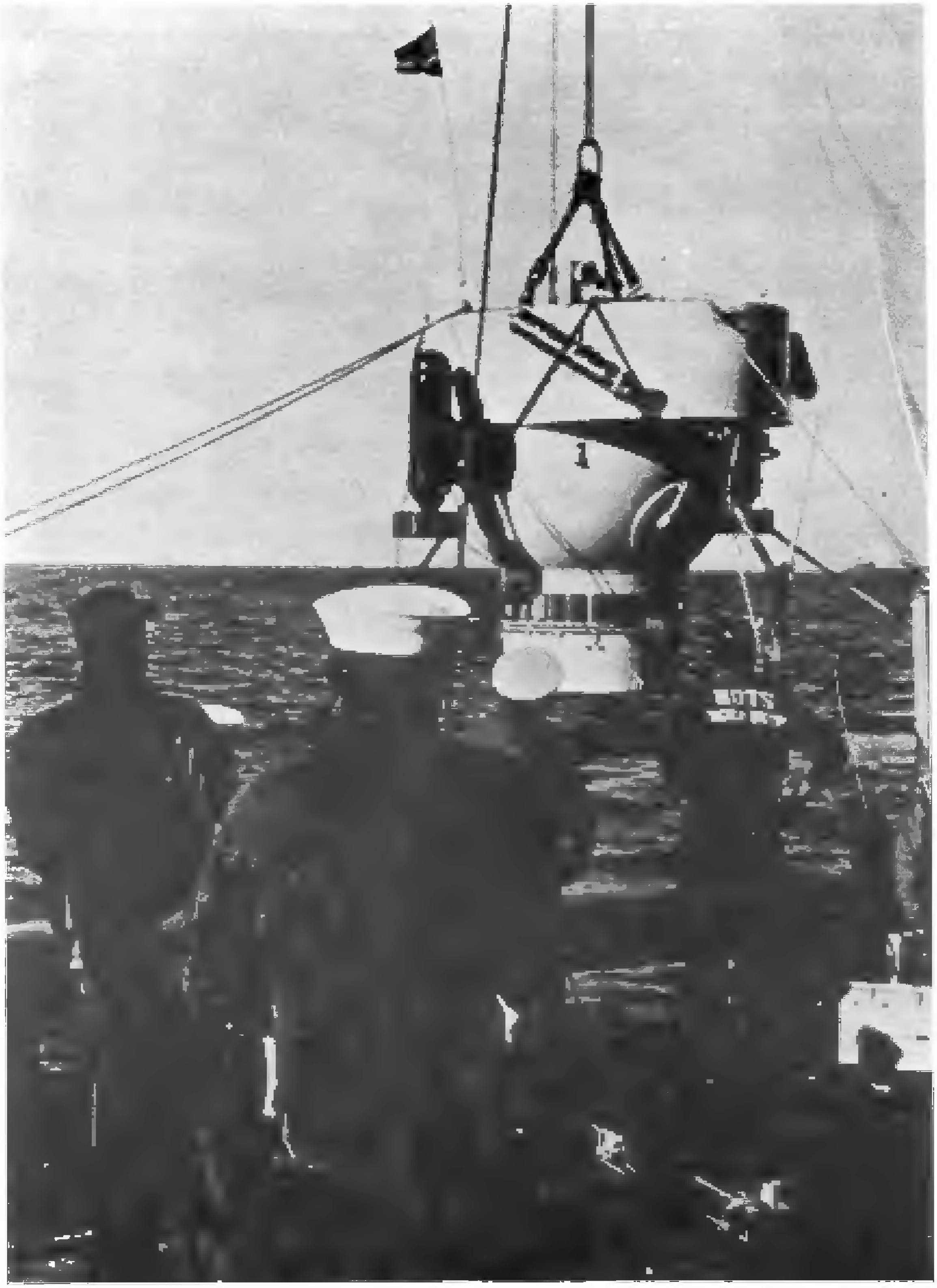


Figure 3-21 DEEP JEEP Vehicle

Figure 3-22 CUBMARINE Vehicle

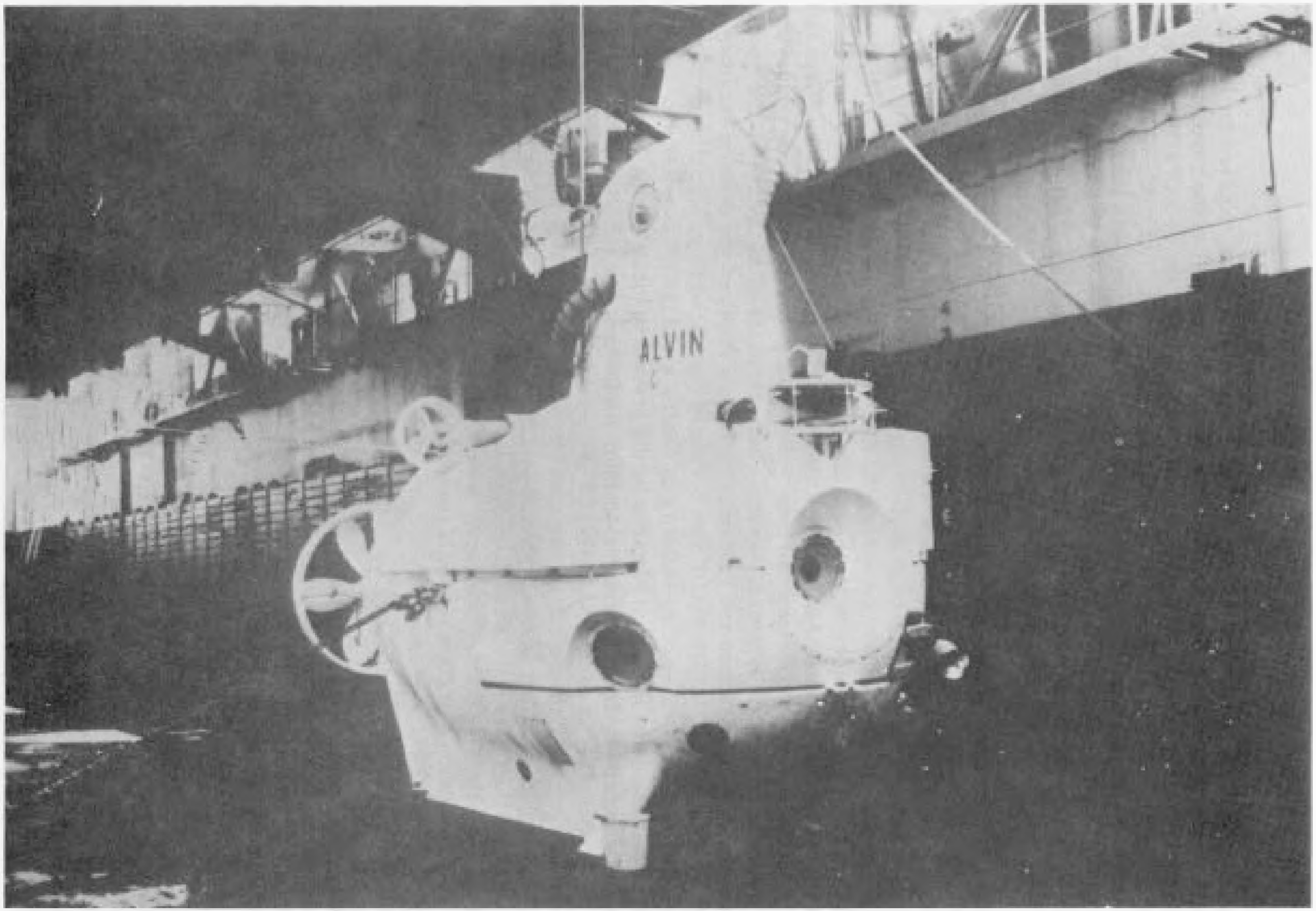


Figure 3-23 ALVIN Vehicle

fatigue. Normally 8 hours of maintenance time between dives was required for battery charging and normal maintenance; this required dry docking in the well of the supporting Landing Ship Dock (LSD) (Fig. 3-24). The viewing ports were insufficient in both size and location, accentuating the need for an improved external lighting system. ALVIN's installed manipulator arm had a working capacity of only 50 pounds, limiting the tasks that could be undertaken as well as the submersible's capacity to carry an observer. The limited reserve buoyancy in the system provided practically no lift capability. The maximum operating depth was 6000 feet.

ALUMINAUT - Largest of the submersibles, and designed for four times the endurance of ALVIN, ALUMINAUT (Fig. 3-25) generally was not as effective for the tasks of search, identification and recovery. ALUMINAUT amassed a record of 15 evaluated contacts, 7 of which were aircraft debris. Although duplicating ALVIN's 60 days of availability, and spending a comparable number of hours submerged, ALUMINAUT amassed nearly twice the number of days lost to maintenance failures and in a standby status. The standby time tends to weight these statistics against ALUMINAUT since she was placed in a standby status on several occasions after the weapon had been located and recovery operations employing ALVIN were in progress. However, several characteristics of ALUMINAUT left room for improvement. Hull inspection and routine maintenance required the docking services of the LSD every 4 or 5 days. ALUMINAUT was normally restricted from operating in rugged canyons and ravines because of its inability to readily avoid the terrain features and still operate within the short distances required by the prevailing visibilities. Lack of an external photographic capability and a proven manipulator limited her identification and recovery usefulness. It should be noted that ALUMINAUT did possess sufficient lifting capacity to recover the weapon but the operation was considered too great a risk to the vehicle and its crew. Although possessing several types of equipment intended to provide a navigation capability, ALUMINAUT was not able to determine its geographic position except by dead reckoning from the dive point. In an environment where visibilities of 40 feet were the maximum, this navigation system was totally inadequate.

IDENTIFICATION SUMMARY:

Identification of contacts by acoustic means was impossible. Thus, all contacts not initially acquired either visually or by photograph, required a revisit. The possibilities for revisit were by diver, underwater TV, towed cameras, camera equipped unmanned vehicles and manned submersibles. All were useful and all contributed to the successful conclusion of AIRCRAFT SLAVOPS MED.

One aspect of the operation affecting search or identification capability was that of subsurface navigation. Given that the DECCA Hi-Fix system accurately positioned the surface control ship, how accurately could the relative position of the submersibles be determined. Only the USNS MIZAR (Fig. 3-26) possessed an accurate tracking system, called Underwater Tracking Equipment (UTE). All other tracking systems were either grossly inaccurate or range limited in determining where the search vehicle had been or where it was to go.

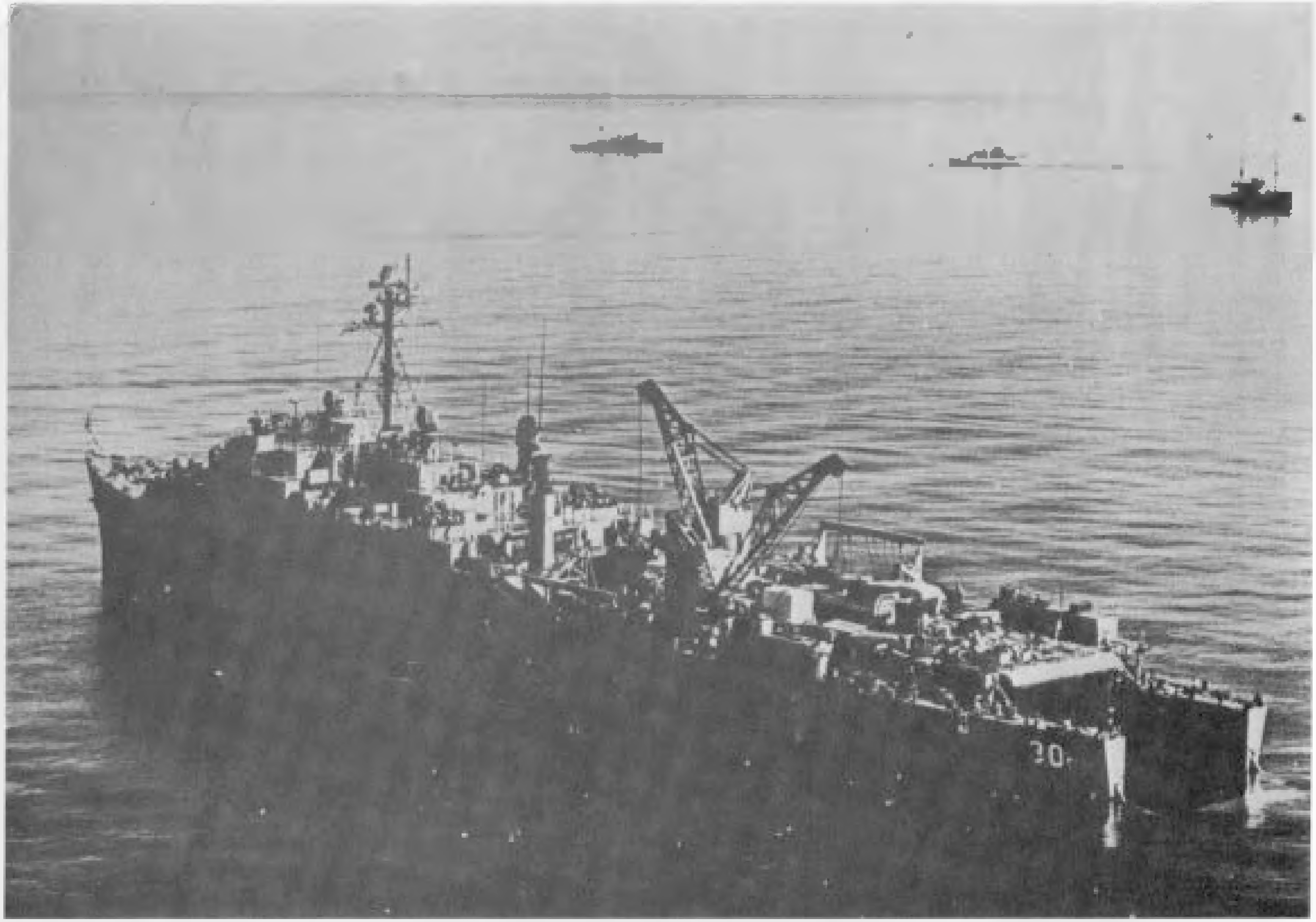
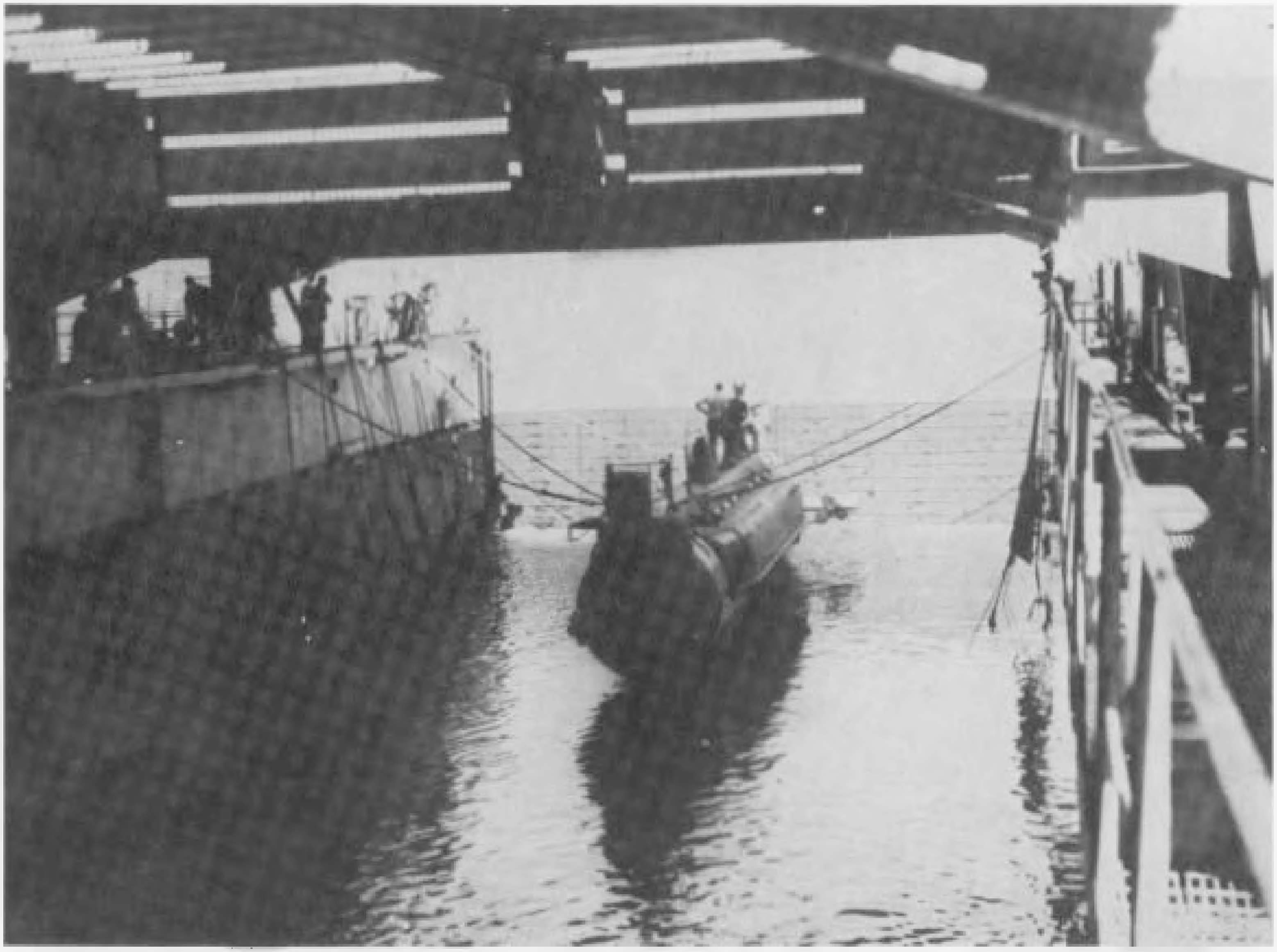


Figure 3-24   Landing Ship Dock (LSD)



Figue 3-25   ALUMINAUT Vehicle

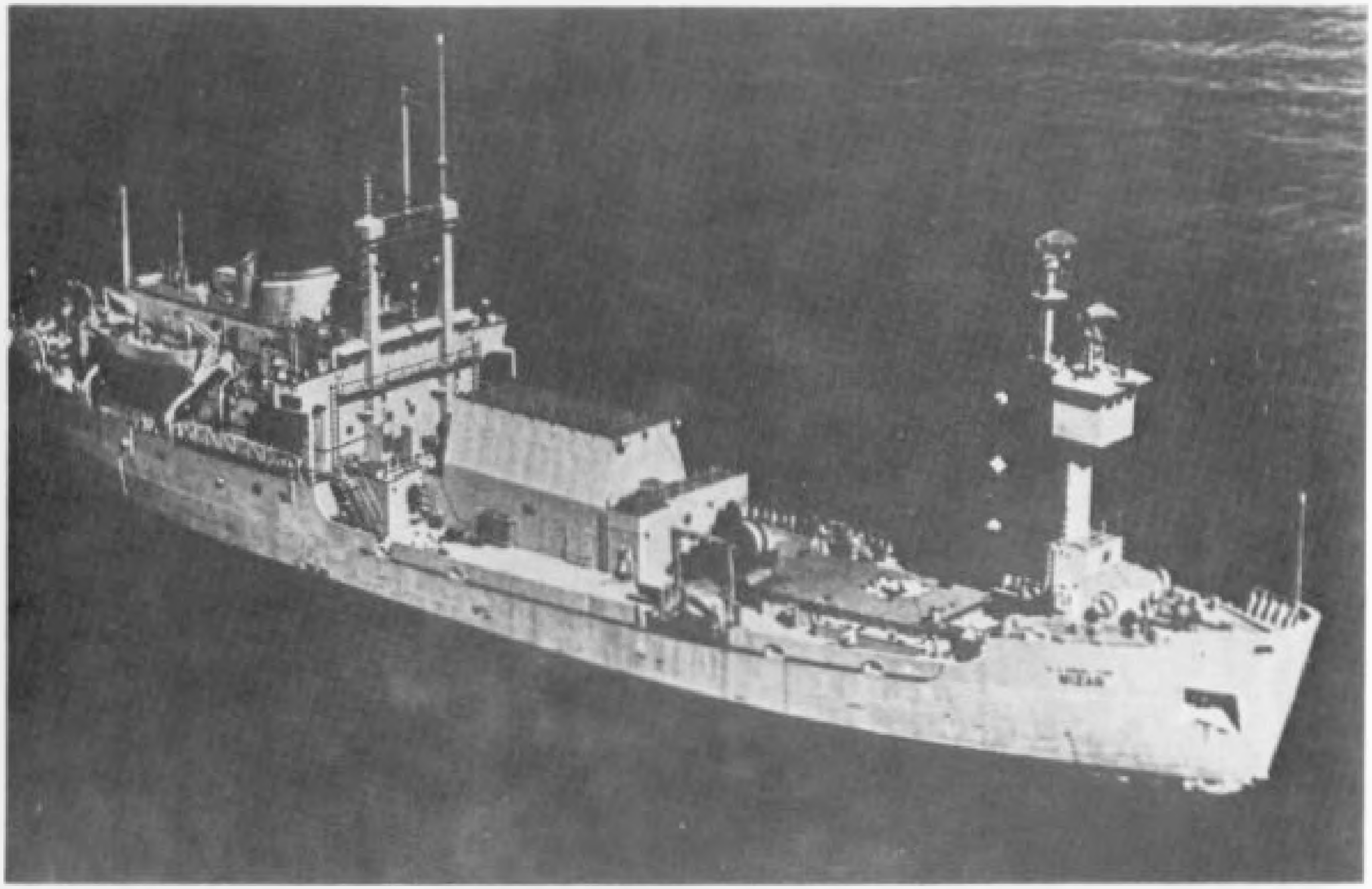


Figure 3-26 USNS MIZAR

Search under any of the other systems was essentially random. Some navigation capability was provided by bottom planted transponders or pingers for use in conjunction with the vehicles sonar. However, the profusion of frequencies and the loss of line-of-signal in rough terrain severely handicapped these systems. The more sophisticated navigation systems installed in the ALUMINAUT were troubled with material deficiencies and were never operated satisfactorily.

Recovery:

Not the least of the problems facing CTF-65 was the recovery of the weapon once it had been located. Three separate plans ALPHA, BRAVO, and CHARLIE, were formulated for the recovery of Contact #261. While all indications were favorable that this contact was in fact the missing weapon, it continued to remain hidden until the CURV cameras and TV caught a glimpse of the weapon shape enroute to the surface (Fig. 3-27), but positive identification could not be effected until the bomb was on the deck of USS PETREL.

Plans ALPHA and BRAVO both involved the use of ALVIN to place pendants to the unit, but neither method proved successful.

Plan CHARLIE called upon the USNS MIZAR to play a primary role. It was to lower a Danforth anchor, with a frame-like assembly called "POODL" (Fig. 3-28), attached to the anchor line, to a point near the weapon. The use of a 16 KC transponder on the "POODL" in conjunction with the UTE, enabled MIZAR to place the assembly within 80 feet of the target. The two lifting pendants on the "POODL" and the one on the anchor were to be attached by ALVIN. Only the lift line on the anchor could be attached to six shroud lines, the two lifting pendants from the POODL were fouled and could not be used. The decision was made to lift. In the process, the lifting pendant parted between the anchor and the weapon allowing the weapon to settle to a depth of 2800 feet. The failure was apparently caused by the nylon lift line fouling on the anchor or perhaps by contact with a jagged stone out-cropping upslope from the weapon.

The fourth plan (unnamed) was to use CURV to attach three locally fabricated grapnels to the chute and its shroud lines. Each grapnel was to have its own 5/8-inch braided nylon lift line. One of the three was to be used as a "lazy tether" line, long enough to reach to the bottom of the deepest canyon in the area. Before this plan could be put into action, several tasks had to be accomplished. When the parachute enshrouded object was sighted on 15 March, CURV was ordered readied for use in depths to 2800 feet. Since its design depth was 2000 feet, some 900 feet of control cabling had to be spliced into position, a sea test conducted off the coast of California and then the vehicle shipped to Palomares and installed on board the USS PETREL (Fig. 3-29). Having demonstrated its ability to recover an object from 1050 feet in the Palomares area, CURV was ready to perform when the target was relocated on 2 April. On 4 April, CURV successfully attached the first grapnel to the apex of the chute (Fig. 3-30). To this grapnel was attached 3200 feet of 5/8-inch braided nylon and an additional 1500 feet of 3/4-inch braided nylon line on a buoy. A second grapnel was entangled in the chute shroud lines and connected to a second buoy by 5000 feet of 5/8-inch

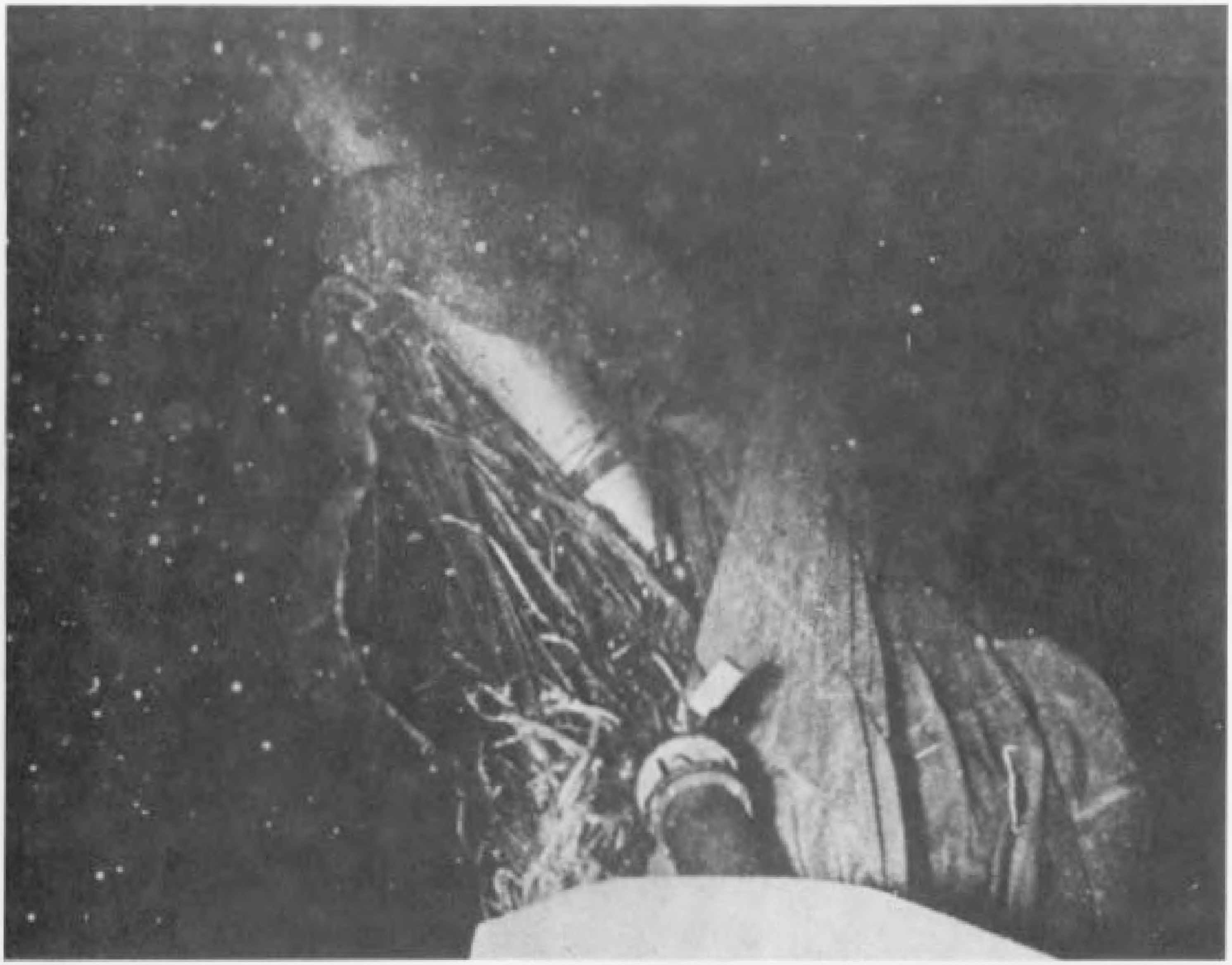


Figure 3-27 Underwater CURV Camera Shot During Lift

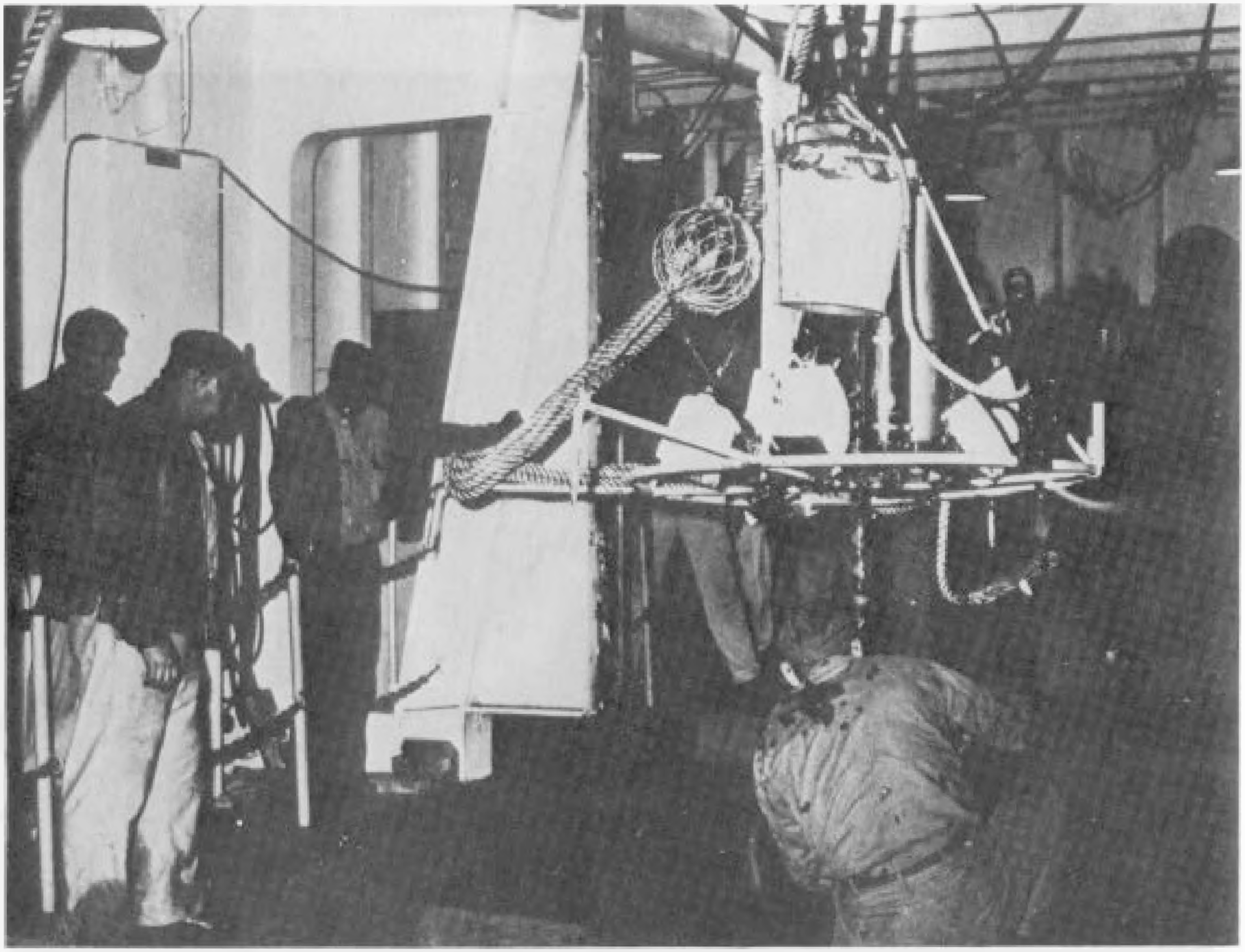


Figure 3-26 "POODL" Assembly

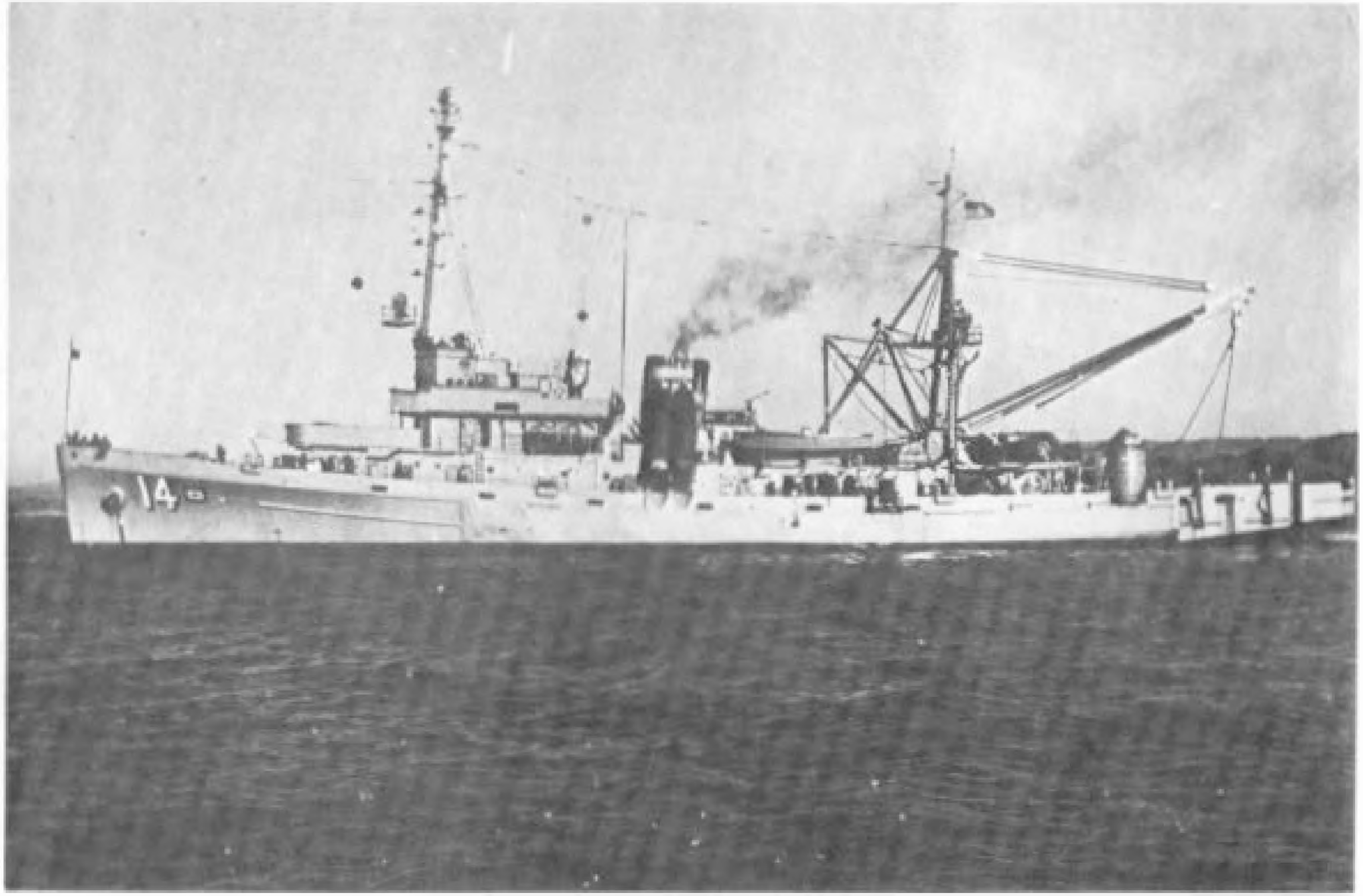


Figure 3-29 USS PETREL

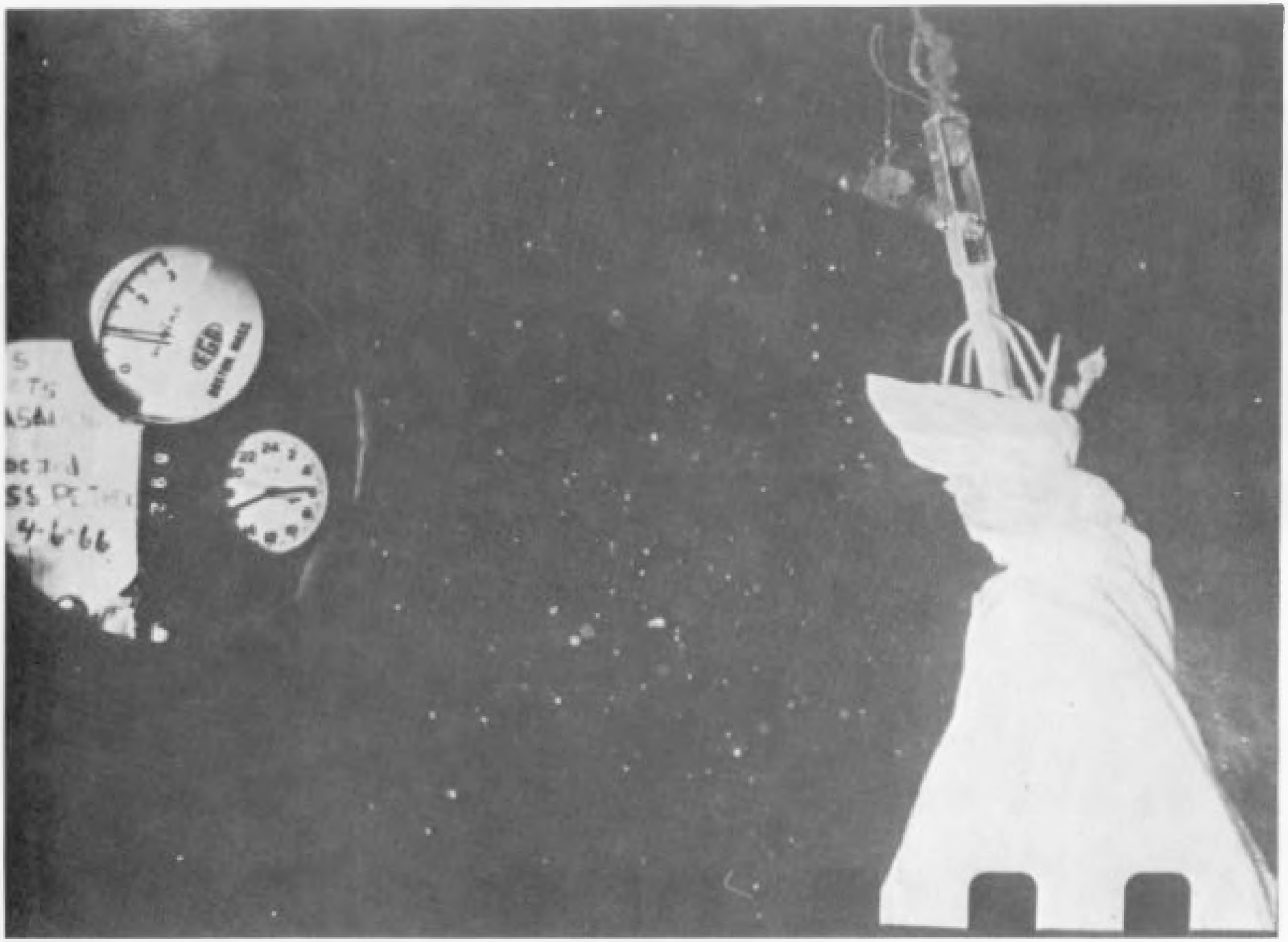


Figure 3-30 First Grapnel Attachment

braided nylon line on 6 April. Subsequently, ALVIN reported that the weapon had moved some 300 feet down slope and so the third grapnel was sent down on CURV lest the weapon move below the depth capability of the CURV. While attempting to engage the third grapnel, CURV became entangled in the parachute and the decision was made to commence the second lift attempt. The two-lift lines were engaged to PETREL's starboard amidships capstan through the starboard diving and boat booms so that both lines were hauled in simultaneously while the CURV's lines were tended over the stern. Taking up the slack on the apex line first, the two lines made the lift, and while the CURV lines were hauled in at the same time, care was taken not to put a strain on the parachute by that means. It is interesting to note that the action during lift was recorded by the TV and cameras aboard CURV (Fig. 3-27).

When the weapon reached a depth of 50 feet and the top of the parachute was at the surface, divers transferred the load to a bridle extended from the ship's main boom and the long lost nuclear weapon was swung aboard (Fig. 3-31), and gently lowered to a wooden cradle to await the rendering safe procedures of the EOD team. A message of "Mission Accomplished" was transmitted to the Chief of Naval Operations.

RECOVERY SUMMARY:

After the weapon was located on 15 March and its condition determined, TF-65 concentrated on the problem of devising a method of recovery that was within the capability of the material and equipment in hand or readily available. Because of the precarious perch of the weapon and the interaction of the currents on the parachute, time was of the essence, for any significant delay might mean another loss of the weapon and a possible recovery from a depth as great as 3900 feet. Not only would this conditon have put the bomb beyond the reach of CURV, but it would have multiplied the difficulties of recovery several fold. There was always the chance that the weapon might slip into a hole or sink into the silt and ooze of the bottom making search and recovery impossible.

Faced with these discouraging possibilities, CTF-65 approved the three proposed recovery plans utilizing the best available equipment and expertise. Each plan failed in turn, and in fact, plan CHARLIE resulted in the loss of the weapon to greater depths. Because of the ability of CURV to descend with a grapnel attached to a line of sufficient strength to lift the weapon and place the grapnel securely in the folds of the chute, the CURV was called to task. CURV accomplished its mission and the missing nuclear weapon was recovered 81 days after the bombs fell on Palomares (Fig. 3-32).

OPERATIONAL SUMMARY:

Review of all aspects of the at sea portion of AIRCRAFT SALVOPS MED presents a rather impressive set of problem accomplishments, lessons learned, and a genuine admiration for the men and machine teams that deserve gratitude and praise from the people and governments of both Spain and the United States. In summary, 454 contacts were made. Of these contacts, 201 were identified as aircraft debris and recovered, while 103 were identified as

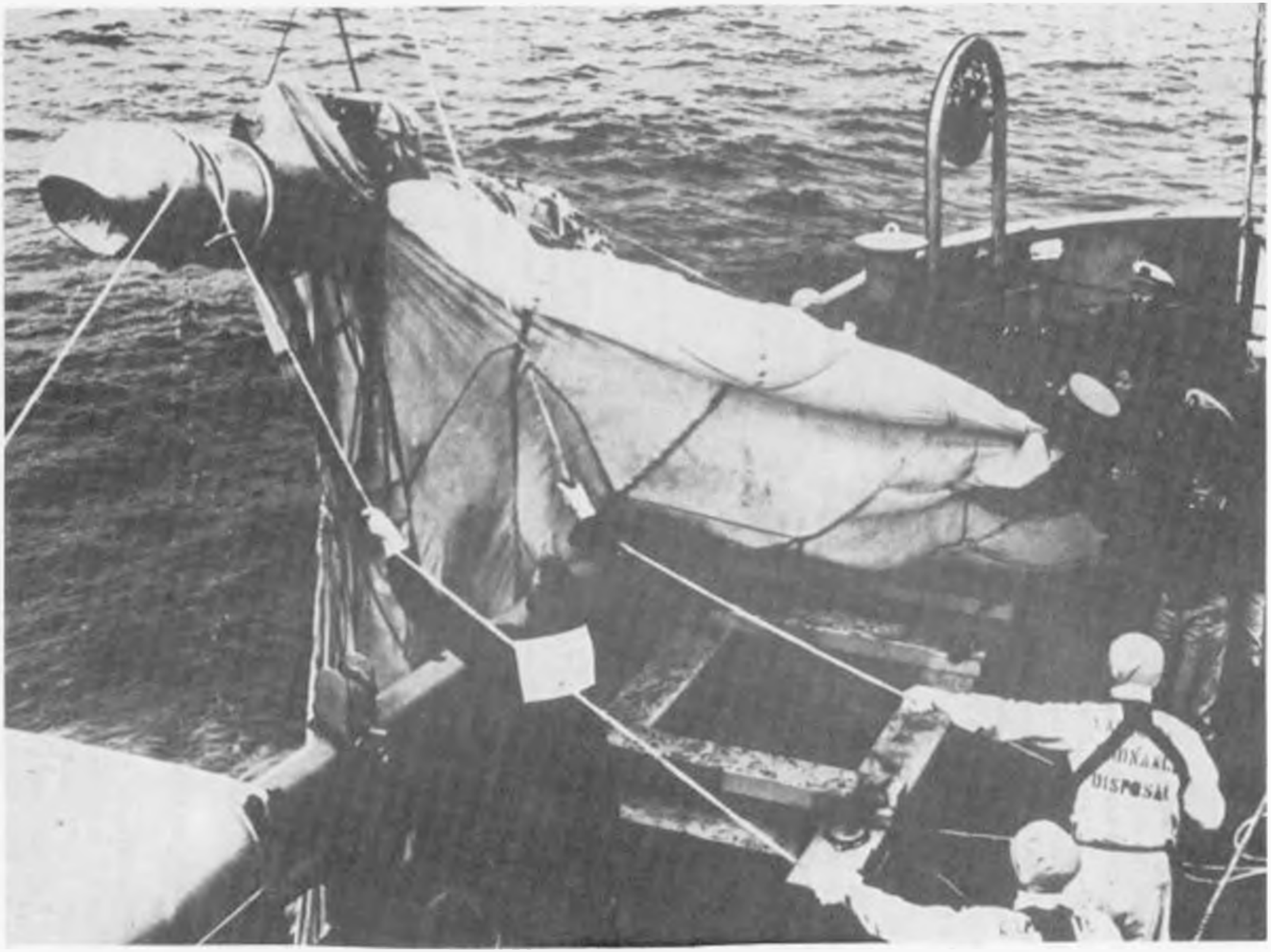


Figure 3-31 Swinging the Weapon Aboard

Figure 3-32 Gen Wilson and ADM Guest with Recovered Bomb

non-aircraft debris. Most of these contacts are plotted in Figure 3-33. The remaining contacts were not identified or were abandoned once the weapon was found.

LOGISTICS AND SUPPORT:

The success story of TF-65 was made possible through the combined efforts of supporting personnel in the United States. Coordinating and guiding this rather unusual endeavor was the TAG. In addition, the combined assets of the Naval establishment as well as the country's industrial complex were on call and responded with all possible haste when a need was identified.

Logistics:

The magnitude of effort required to support the large contingent of men and equipment over 3000 miles away from the source of supply, was significant, particularly because many requirements bore a top priority label. It was obvious that normal supply channels through chain of command could not provide the special materials within the time element required, and in some cases, never. As a result, direct channels were opened to the TAG where each request was discussed and the appropriate action taken. Most of the special materials were flown to the site by one of the routes shown in Figure 3-34.

During the period from 17 January to 13 April, a total of 34 surface ships played a part in supporting TF-65. Added to this armada were at least six utility boats, not to mention the smaller craft from the usual complement of the ships assigned. The support of these ships and their crews was not a large task for the Navy, hence all normal logistic requirements were satisfied through regular Navy supply channels. For many of the ships and their crews, it meant days of little visible progress and practically no shore leave. While not a particularly critical problem, the situation did little to boost the average sailor's morale.

At the outset of the support effort, a survey of methods and equipments both foreign and domestic was conducted by the TAG. From this survey, the items that showed the most promise were proposed to CTF-65 and if feasible were ordered to Palomares. Some items not in being, were manufactured, often resulting in the receipt of untried and untested systems for which little expertise in operation or maintenance was available. Certain of the assets could not be shipped or moved immediately. For instance, ALUMINAUT was too large to be airshipped so it was transported on board the USS PLYMOUTH ROCK, a trip which required 10 days. ALVIN required partial disassembly for air lift, with subsequent reassembly upon arrival and so arrived at Palomares on the same day as ALUMINAUT. People, an easy to ship asset, were delayed because of the necessity for security clearances. Some were citizens of foreign countries which compounded the clearance problem.

Major technical and logistics support for AIRCRAFT SALVOPS MED was supplied by the Supervisor of Salvage in the then Bureau of Ships, by the Director of the Deep Submergence Systems Project, by the Chief of Naval Research, and by the Oceanographer of the Navy, all of whom were represented on the TAG. The main effort of the Supervisor of Salvage

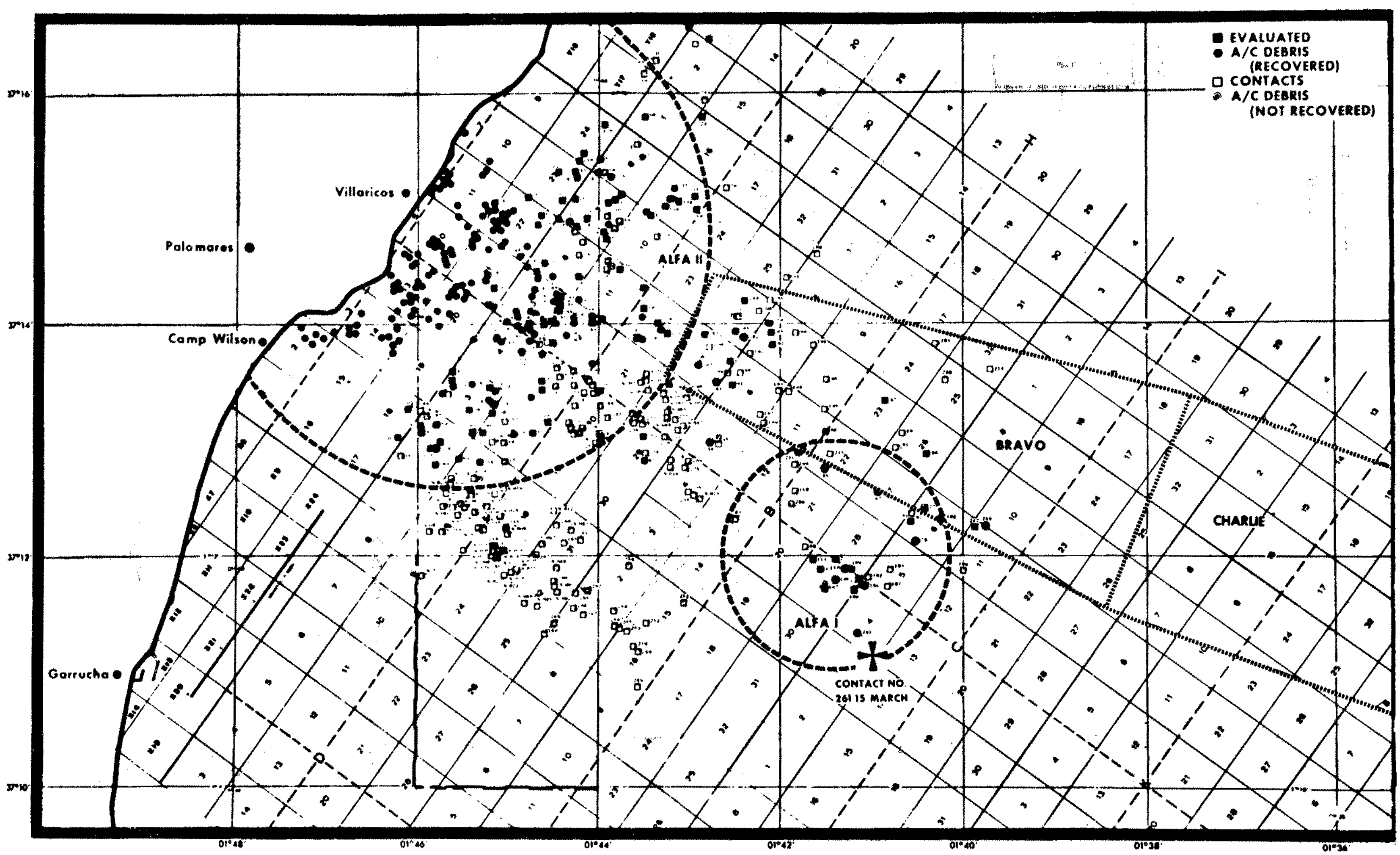
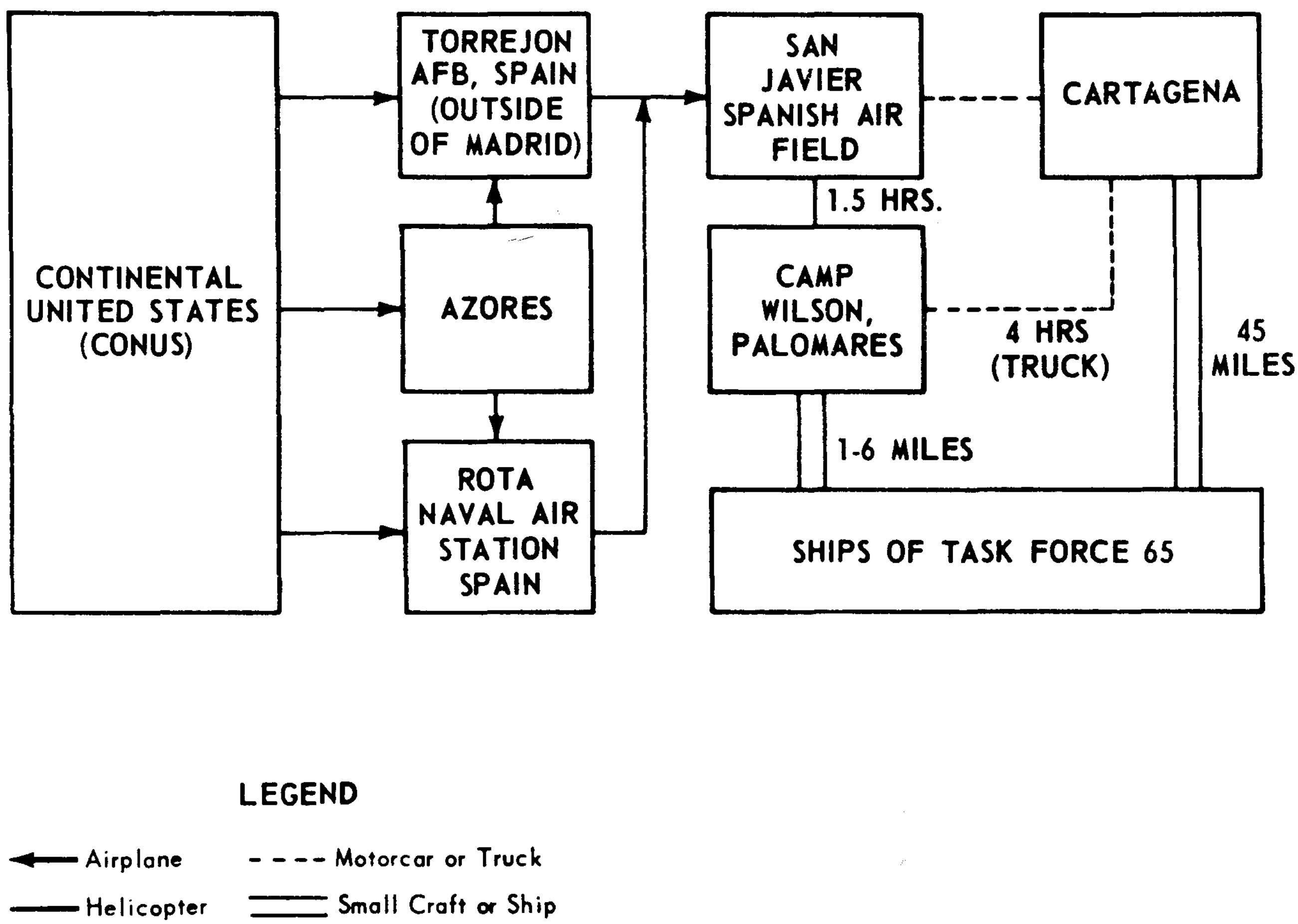


Figure 3-33 Contact and Debris Pattern



NOTES:

1. Total/one way intercontinental airlift of Navy cargo: 250,000 lbs.
2. Total flight time, Andrews AFB (CONUS) to Torrejon AFB: 10.5 hrs. (2875 miles)

Figure 3-34 Transportation Flow from CONUS to Task Force 65

involved contracting, procurement, and modification of commercial equipment and the procurement of all civilian personnel services. Ocean Systems, Inc. was contracted to manage civilian participation and to provide consulting and technical assistance. The Director of Deep Submergence was tasked to provide the services of ALUMINAUT and the MV PRIVATEER, its mother ship (Fig. 3-35). ALVIN and USNS MIZAR were provided by the Office of Naval Research. The Oceanographer of the Navy provided the scientific assistance required to set up the DECCA Hi-Fix navigation system, a product of Great Britain. To the foregoing tasks was added the identification and evaluation of the environmental parameters indigenous to the Palomares off shore area. From the Mine Defense Laboratory came the SEALAB divers, while the Naval Ordnance Test Station furnished DEEP JEEP, underwater TV and CURV plus the technical expertise for operation and maintenance of these systems. And finally, the Commander Military Sea Transportation Service ordered the USNS MIZAR, DUTTON, BOYCE, and the SS ALMA VICTORY into service in support of TF-65.

As a supplement to the TF-65 staff, a Tactical Analysis Group was formed to collect and analyze data, assist in the formulation of the daily search plans and assignments, and the calculation of the Search Effectiveness Probability (SEP*). This group consisted of three naval officers, a civilian oceanographer, and a civilian mathematician. By midnight on 14 March, the day before the missing nuclear weapon was sighted, the search effort in area Alpha I had resulted in an overall SEP of between .30 and .35, while Alpha II had an SEP of from .82 to .86. By comparison, had the weapon not been found on 15 March, much further search in Alpha I was indicated. Figure 3-36 illustrates the SEP for each portion of Alpha I, the summation of which resulted in the overall SEP noted.

Transportation:

As were all support facilities, transportation was woefully lacking during the first few days of AIRCRAFT SALVOPS MED. Vehicles, such as they were, had to be borrowed from commercial vendors of Palomares and the nearby villages, from the Guardia Civil, or the Spanish military authorities. The problem was solved through the use of civilian and military aircraft, Navy ships, and Air Force trucks. The U.S. Air Force provided 47 special logistic flights from the United States to Spain in support of TF-65 in addition to many CONUS and European intra-continental flights. Over 250,000 pounds of cargo were airlifted to the Task Force. In addition, many of the ships that were to take part in the operation arrived with cargo, these in addition to the regular supply ships who serviced the Task Force as part of the Sixth Fleet. Daily flights were flown from Torrejon to San Javier and there the cargo transferred to helicopter for movement to Camp Wilson and the waiting landing craft (Fig. 3-37).

As can be seen from Figure 3-38, there were no ship landing facilities at Palomares, making the landing craft indispensable during the logistic phase of the operation. However, inclement weather and high winds and seas made the operation of small craft oftentimes treacherous

* Note: SEP was defined as "the probability that if the target were in a specified area, then it would have been detected and identified with a specified amount of search effort. The parameters used in determining the SEP included the sweep width of the individual sensor, navigational accuracy, contact identification, and search procedure.

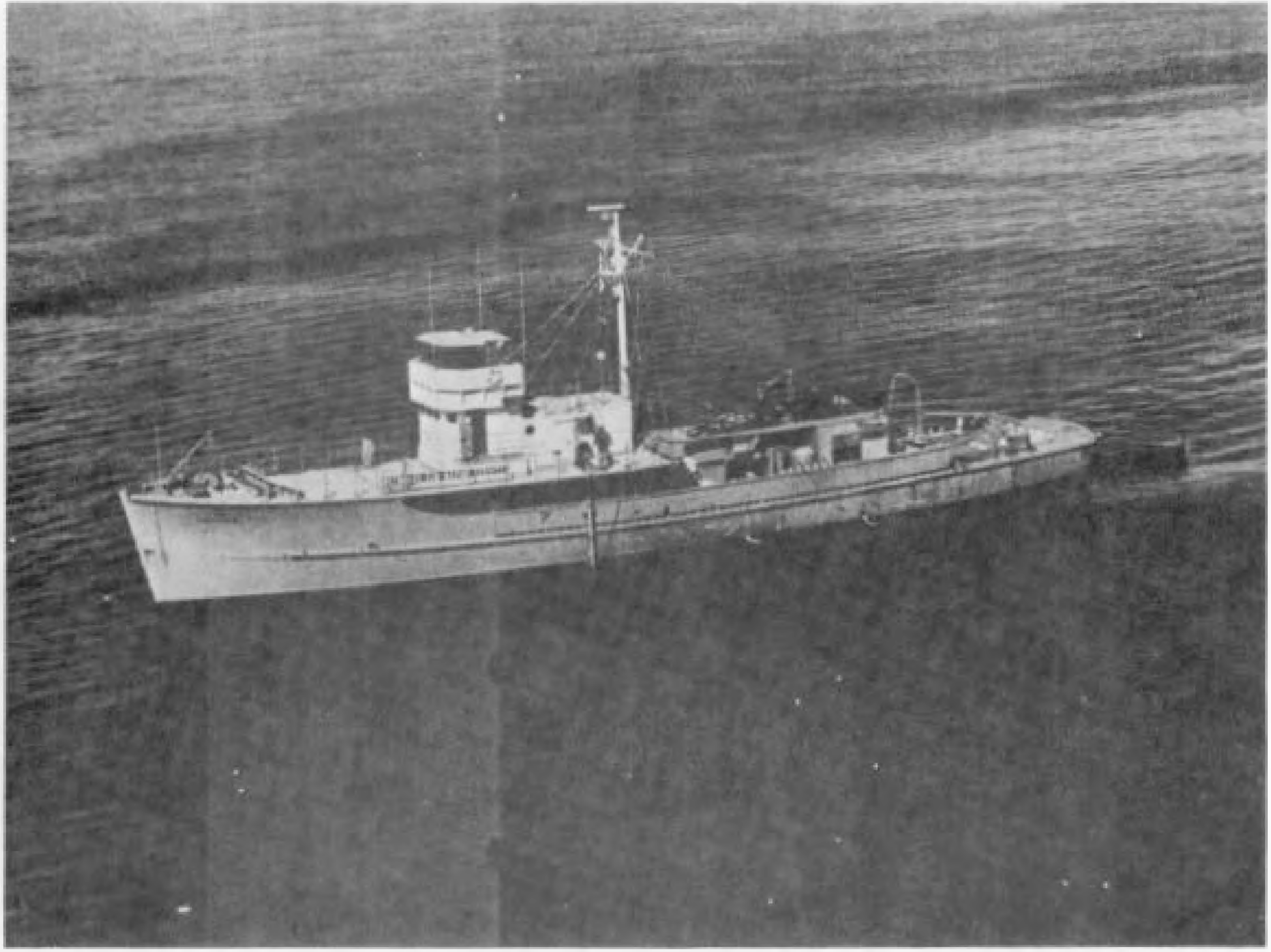
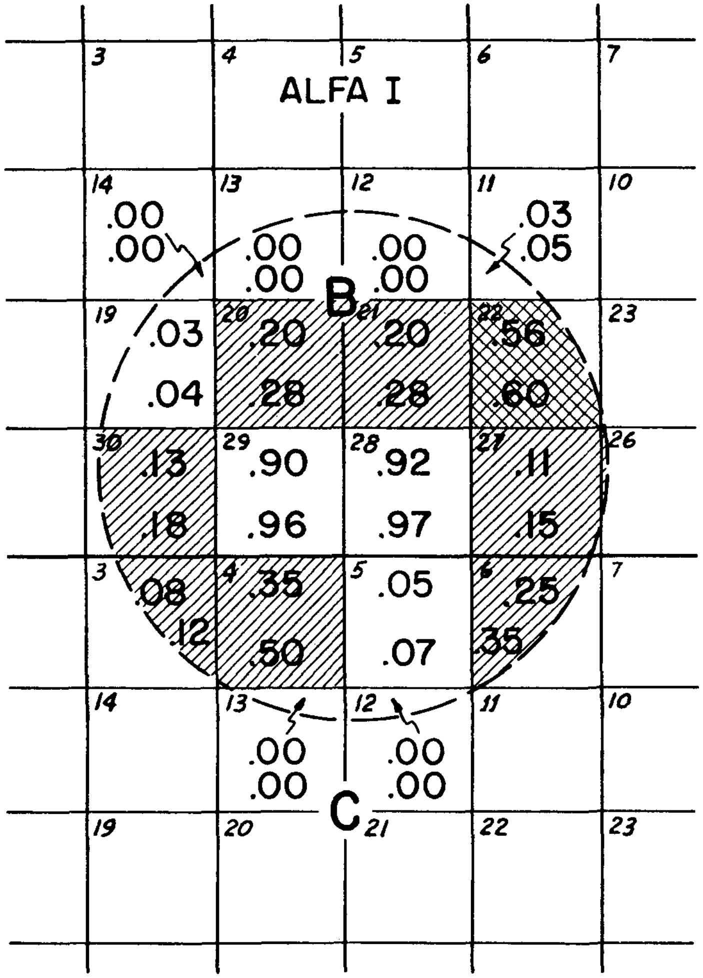


Figure 3-35   MV PRIVATEER



Notes: (1) SEP is given by the large bold faced numbers. The small light faced numbers give the square designation.

(2) The two values of SEP in each square result from two different assumptions about visual detection (optimistic and pessimistic).

(3) Shading is based upon the larger of the two values for SEP.

LEGEND

- $.95 \leq SEP \leq 1.00$
- $.50 \leq SEP < .95$
- $.10 \leq SEP < .50$
- $.00 \leq SEP < .10$

Figure 3-36 Search Effectiveness Probability in Alfa I

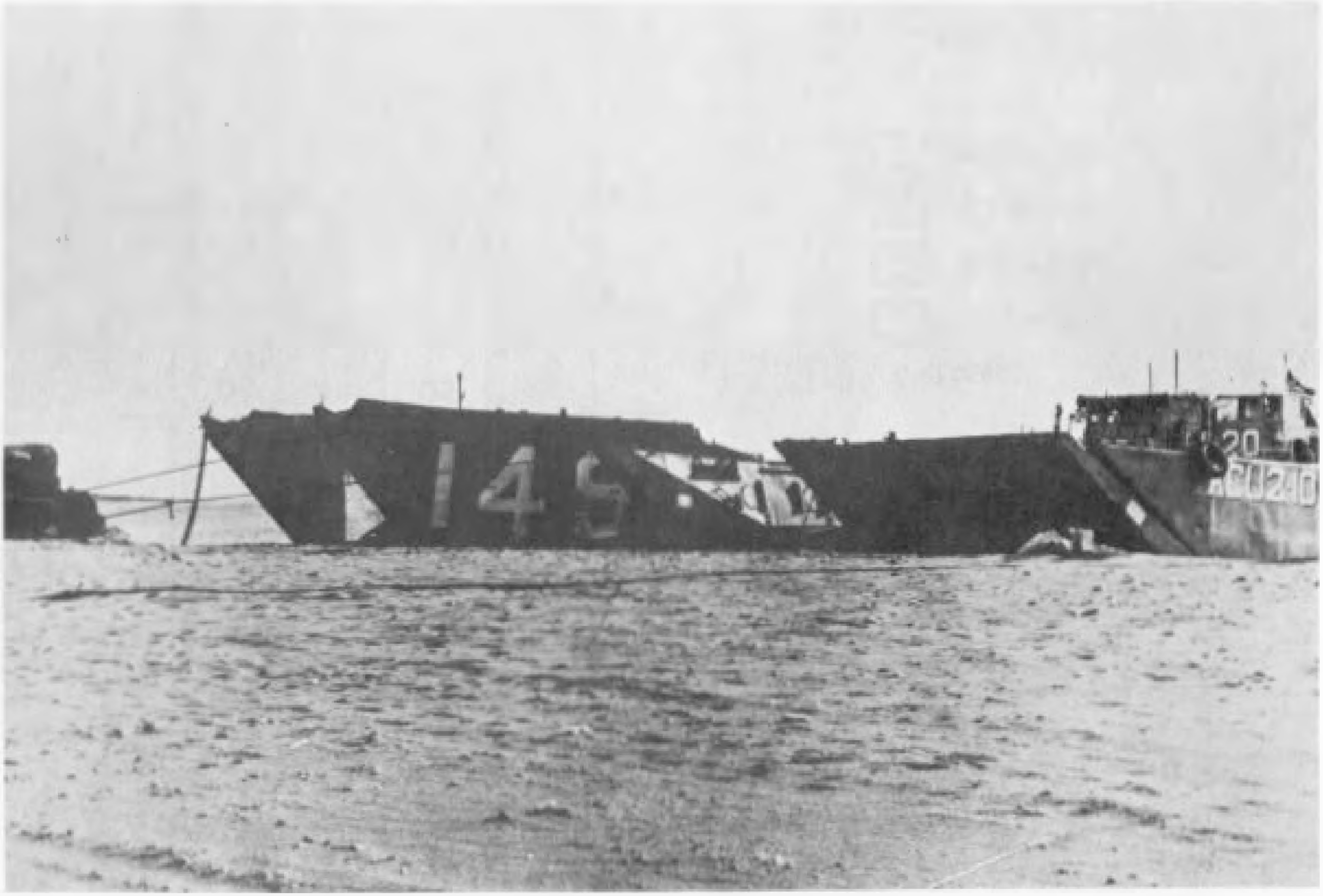


Figure 3-37 Landing Craft at Camp Wilson

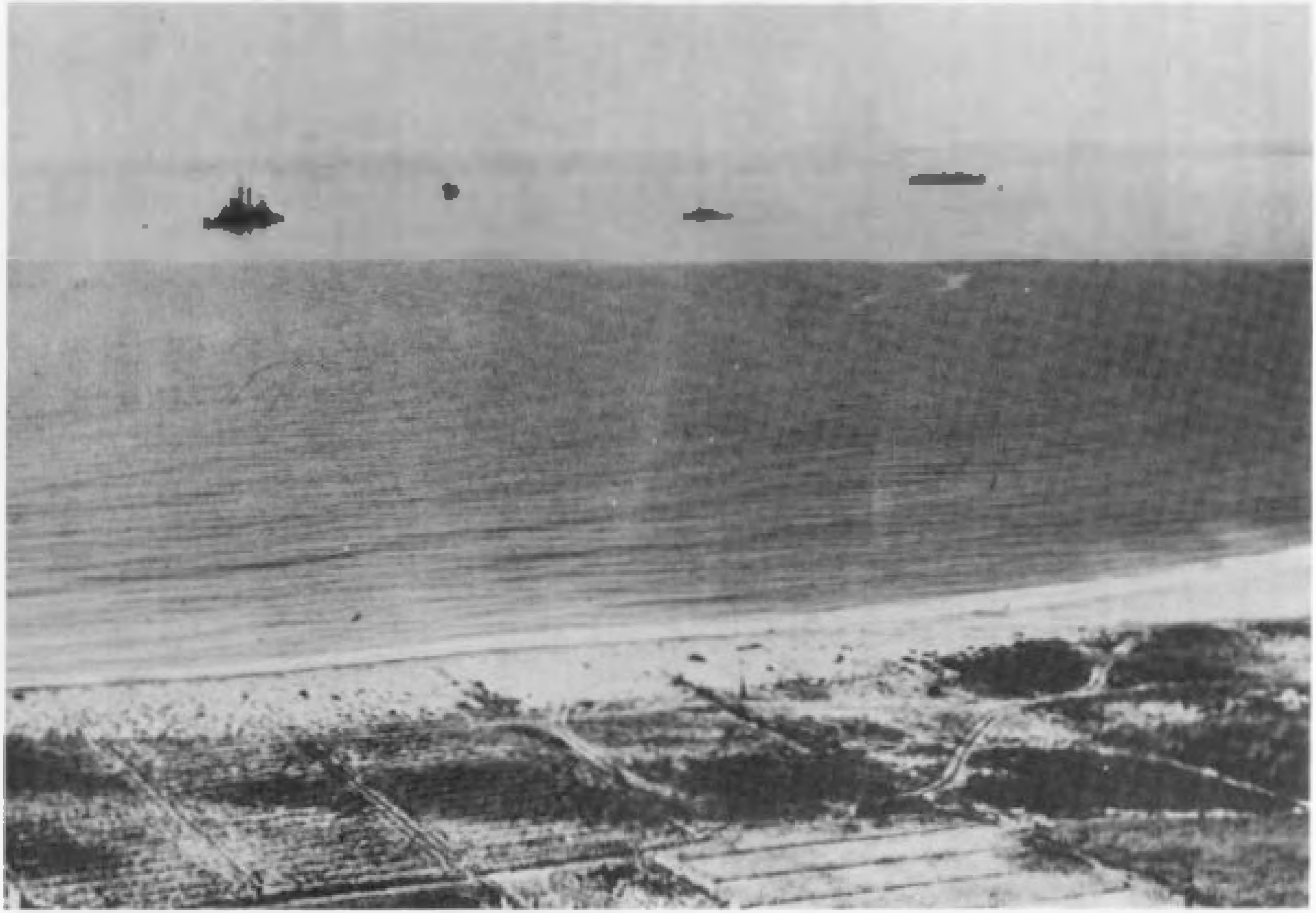


Figure 3-38 Beach at Palomares

or impossible. When the need arose to service various smaller ships, they were taken to either Cartagena or Garrucha where reasonable protection and pier facilities were available.

Along with the absence of any pier facilities (Fig. 3-39), Camp Wilson lacked warehouses or other buildings in which to receive and process the bulk of the material and equipment flown in. As a result, the material began to pile up on the beach and lost its identity. In fact, many items were never used or even unpacked and as such represented an over supply, manifesting the desire of TAG to insure that CTF-65 had all the material he could possibly use.

Operational Support:

As part of the support provided to the Task Force by its own supply and repair ships, three particular tasks were noteworthy:

The task of supporting ALVIN and ALUMINAUT fell upon the LSD assigned to TF-65. While not specifically suited to this role, the LSD did provide a dry dock facility for both as well as machine shops and other repair facilities (Fig. 3-40).

The Navy had the task of removing the aircraft debris from Spanish soil and dumping it at sea after it had been collected and stacked on the beach (Fig. 3-41). The Navy modified two barges and towed them from Cartegena to Palomares where the debris was loaded on board. The barges were then towed out into the Atlantic Ocean and there off loaded.

A program for the sanitization of the land in and around Palomares, produced some 4800 barrels of contaminated top soil (Fig. 42). Once land troops had loaded the barrels, delivered from Italy by the Navy, they had to be placed aboard the USNS LT. BOYCE (Fig. 3-43) for shipment to Charleston, South Carolina and thence to Aiken, South Carolina for burial in the Atomic Energy Commission waste depository.

Logistic Summary:

The success of rapid and effective logistics support of AIRCRAFT SALVOPS MED was made possible by the establishment of a highly qualified Technical Staff (TAG) located at the nerve center of the nation and empowered to make the decisions and expend the funds required. Both the urgency of the mission and the serious lack of operational equipment to accomplish the mission generated many specialized logistic problems not normally encountered. The priority assigned were appropriate to a national emergency, which in some respects, this was.

Figure 3-39   Aerial View of Camp Wilson Area

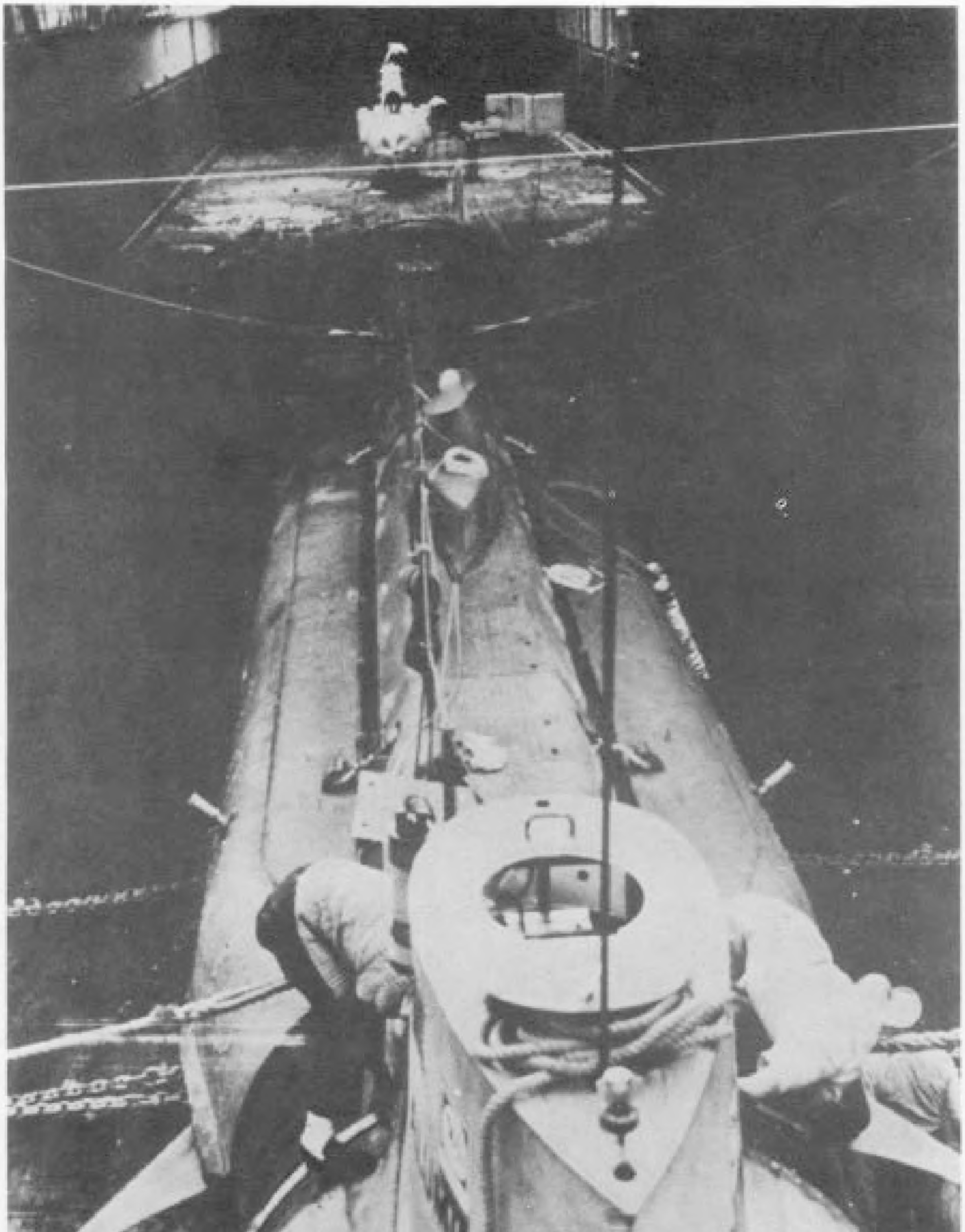


Figure 3-40   LSD as a Dry Dock Facility

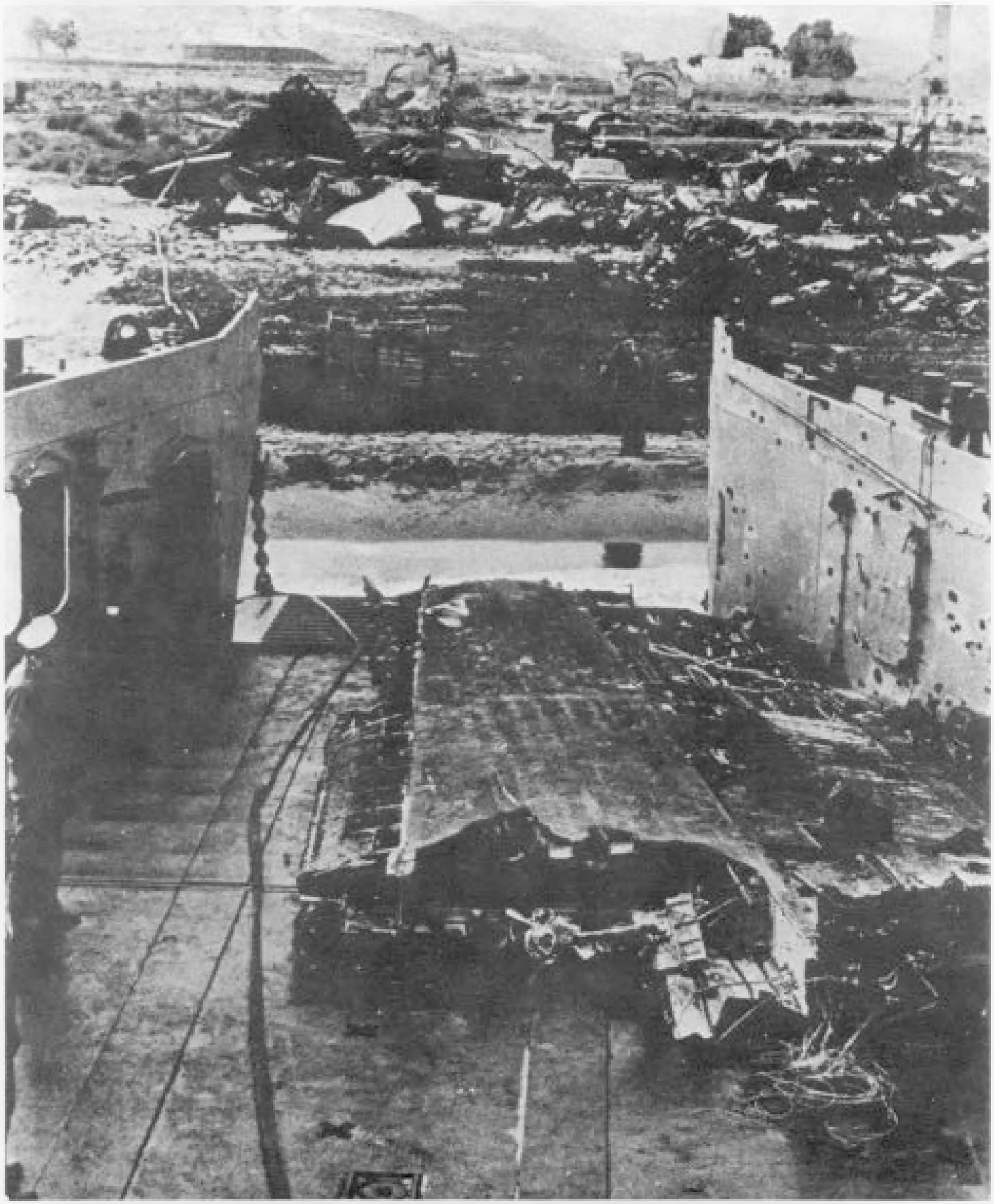


Figure 3-41 Debris on the Beach

Figure 3-42 Barrel Storage Area

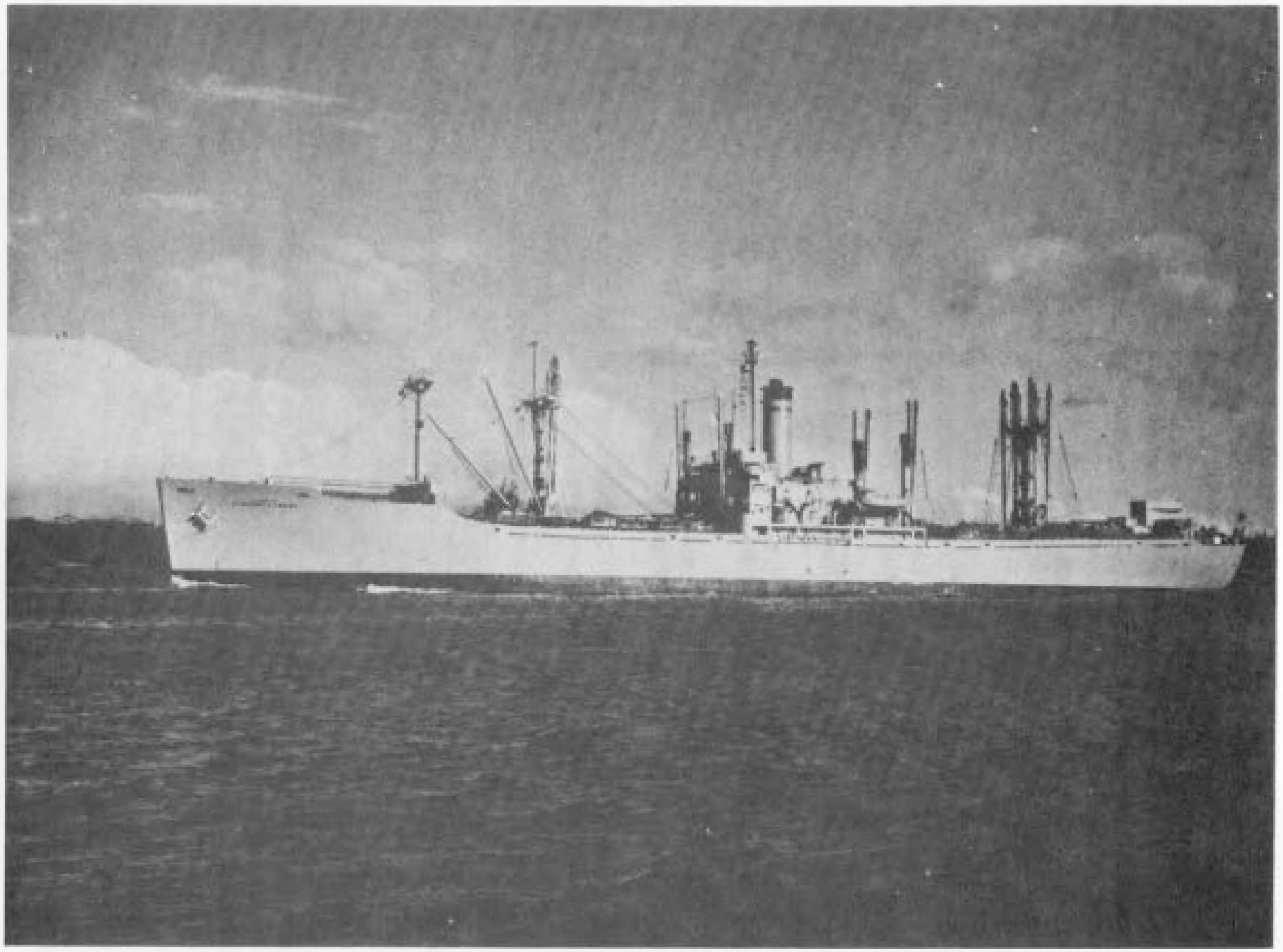


Figure 3-43 USNS LT BOYCE

LESSONS LEARNED:

This section presents the conclusions and recommendations, based on the then current state-of-the-art, and political environment, as described 1 year after the accident in the final AIRCRAFT SALVOPS MED report. Some of the recommendations have been followed, at least as to intent, while others have not, for various reasons, primarily financial. Some of the recommendations were very general in nature and as such appear to have been satisfied in present day organizations and equipments. The current status of Deep Recovery Programs is presented in the Final Analysis portion of this report.

Organization:

In January 1966, the DOD did not have a trained unit or force capable of effective search for and recovery of objects from the ocean floor. TF-65 evolved as a result of decisions made to fill immediate requirements rather than from planned operational requirements.

The Task Force operational concepts were improvised as needs arose.

The establishment of the TAG in Washington, D.C., provided an effective interface between the Task Force and DOD/Civilian scientific and technical resources.

Direct access from the Task Force Commander to the office of the Chief of Naval Operations proved most effective in insuring immediate response.

The diversity and complexity of Task Force components, at times, caused additional problems in both administrative and operational areas.

Upon completion of the recovery operations, all organized expertise accumulated by TF-65 was lost to the Navy when the task force was dissolved.

The need to substitute civilian for military constituents or to provide a nonmilitary appearance in a given search and recovery operation is of real concern in future plans.

Command and Control:

The direction of the search and recovery operations must rest with the on-scene commander, with the guidance and advice of the CNO through the Supervisor of Salvage, who would provide: information on available equipment, procedures for their use, qualified personnel for assignment as operators and to technical advisory or analysis teams; and logistic support from both military and civilian sources. The facilities provided by the assignment of many varied surface ships will not normally produce the multi-channel secure circuits needed by the Commander for inter- or intra-force communications.

The technical advisories sent to CTF by the TAG were invaluable for operational planning.

The detailed SITREPS issued by CTF-65 provided the basis for much of the technical guidance offered by the TAG.

The on-scene commander found it necessary to verify and, where expedient, to modify operational procedures and tactics as experience dictated.

Operational Considerations:

Security:

The integrity of all aspects of search and recovery operations cannot be assured without assignment of a security force of naval warships.

The proximity of the Spanish coastline and the cooperative attitude of the government and its people greatly simplified the security requirement.

Search Preparations:

Weather data and its accurate prediction is an important factor in both the operational and safety aspects of search and recovery operations unless a completely submerged system is available.

Detailed oceanographic data is required for effective search planning.

Bottom sampling and charting must reflect accurate conditions in the search area of concern.

Precise measurement of the characteristics and capabilities of all the equipments under existing conditons must be in hand prior to planning the search. This information must be verified on-scene.

An independent (sea based) navigation system with maximum accuracy is required for surface ship control.

An accurate means of fixing the controlled underwater search or recovery vehicles in relation to the controlling vessel or to the bottom is required. (Accuracy to within 1 foot is desired.)

Search and Identification:

Initial search effort provides useful debris pattern information when properly planned and the results recorded.

Visual search both actual and by remote means proved to be most beneficial except when visibility was severely limited by silt clouds.

Visual backup was the only means of contact verification whether by eye, television, or photography.

Search efficiency is at a maximum using swimmer tactics (0-80 feet depths).

Search effectiveness of hard-hat divers is seriously reduced when the bottom consists of silt or similar composition materials that readily restrict visibility when disturbed (80-600 feet).

Acoustic methods of search lead to maximum contact rate, but provide no positive identification capability. (Maximum depth limited by the particular pulse-repetition rate). Delayed visual follow-up was very difficult and of little value since relocation of a given contact could not be assured. Contact reliability over rough terrain is a minimum.

Tethered vehicles provide maximum endurance, safety, and area coverage. (DEEP JEEP and underwater TV excepted because of control ship moor requirements.)

Manned submersibles provide maximum maneuverability and flexibility, but are endurance limited by life support systems, crew fatigue and power limitations.

Debriefing of system operators immediately after completion of dive is essential to effective planning for the next day's operations.

Debris pattern assessment is essential to search effectiveness probability determination. (Some debris locations were not predictable when based on known environmental parameters.)

Large, less maneuverable submersibles are most useful over level subterrain during the search phase.

Recovery:

Swimmer/diver search procedures provided nearly 100 percent recovery of debris in shallow areas utilizing the lifting capability of the various support ships.

Recovery of debris over 50 pounds was limited to tethered vehicles. (ALUMINAUT had the capability but was not used to recover debris.)

The small manned submersibles were not useful for lifting or line delivery during recovery operations.

A system to decouple surface action is required for recovery by surface ships.

Submersible manipulators, although limited in capacity, are required for light work in the target area.

Design and construction of untried recovery systems by support forces were generally unsuccessful.

Development of a line carrying capability for manned submersibles is essential.

The tethered vehicle equipped with manipulator, sonar, and TV monitor system proved to be most effective in securing the lifting lines to the target.

The danger of vehicle entrapment is always present, but is most likely during recovery operations.

The unlimited endurance of the unmanned tethered vehicle is its greatest asset in recovery requirements.

All recovery vehicles were limited by the current intensity in the area of the target.

LOGISTICS AND SUPPORT:

Sea Transportation:

In spite of the myriad of small craft available, means of moving between ships and between ships and shore were inadequate.

High winds and seas severely restricted small craft operations especially in the vicinity of the beach.

The maintenance facilities provided by the assigned Destroyer Tender (AD) were inadequate in the area of preventive maintenance, resulting in boats which had broken down being out of service for long periods of time.

The landing craft were invaluable in moving supplies to the force and between ships of the force.

Helicopter support is essential to all future salvage operations.

Support facilities required aboard mother ships for submersibles are as follows:

- Crew messing and berthing in air conditioned spaces.
- Center-well for photographic search.
- Bow thruster (laterally thrusting bow mounted auxiliary propellors) for accuracy in station keeping and directional control.
- High speed winches and winch control.
- Photo processing for black and white and color film.
- Adequate fresh water distilling capability.
- Wet and dry laboratories for oceanographer work.
- Cranes for hoisting vehicles aboard when required.
- Docking well wing walls that extend to include a free water area capable of being enclosed in addition to a dry docking area.

Stowage for a supply of ballasting shot, gasoline, oil, batteries, and spare parts, etc.
Air and battery charging facilities.
Shipfitter, electrical, electronic, machine shops, diving locker, diving table, etc.
Accurate underwater tracking capability for towed, tethered, and manned vehicles.
Excellent maneuverability - speed capability of at least 15 knots.
Ability to monitor and control several vehicles simultaneously.
Foul weather recovery capability.
Sufficient communications equipment for all required traffic, local surface and subsurface and long range.
Helicopter flight deck.
Facilities for hydrographic surveys and chart making and printing.

Operational Support:

The Landing Ship Dock (LSD) well deck worked the best of the available launching and recovery facilities for the manned submersibles. (ALVIN's catamaran support ship was not available.)

Flexibility of the LSD was reduced when both ALVIN and ALUMINAUT were on the well deck.

Launching and recovery of the submersibles were extremely hazardous to both equipment and personnel, especially in high sea states.

Facilities aboard the LSD for maintenance of submersibles were marginal and could only be sustained with spare parts shipped direct from the CONUS.

Manned vehicle crew fatigue reduced efficiency.

Vehicle maintenance must be a separate function from the operating crew, particularly in prolonged search and recovery efforts.

While external cameras with strobe lights proved most effective, less than optimum positioning of the lighting reduced visibility, by causing excessive back scatter and "hot spots."

Manned submersibles require improvements in the following areas:

Visibility in all directions.
Maneuverability.
Habitability.
Maximum speed (current limited).
Replenishment (reduced turn-around time).
Sea state capability.
Material reliability.
Underwater navigation capability.
Manipulator flexibility (two arm function).

Lifting capability.
Sonar range and definition.
Endurance.
Anti-entrapment capability.

Tethered unmanned vehicles require improvements in the following areas:

Increased depth capability.
Maximum speed (current limited).
Reduced dependence on mother ship position.
Sonar range and definition.

Better reliability and increased life is required for transponders and pingers. Frequencies must be compatible.

The integration of acoustic detection and immediate visual identification provided the optimum in search effectivness.

A mobile tool kit is required for deployable vehicles, to include a line cutter, penetrating attachments, detachable claws with adjustable grab, latching grapnels, and a double-handed manipulator.

COST OF OPERATIONS:

The cost to conduct the sea search and recovery portion of Aircraft Salvage Operations Mediterranean is outlined in some detail in the following paragraph. However, in retrospect, it is clear that the total bill to the taxpayer was higher than if a specifically designed plan of operations, trained personnel, and the appropriate equipment had been immediately available on 17 January 1966. This statement is no less true today.

COST SUMMARY:

Cost information for that portion of AIRCRAFT SALVOPS MED concerning the search, identification and recovery of the nuclear weapon lost at sea are presented here for historical reasons. It is recognized that inflationary pressures over the intervening 9 years make these figures less than useful, however, the cost listing does provide an indication of relative costs for the selected breakdown.

The total cost for AIRCRAFT SALVOPS MED was $10,230,744 ($126,305 per day).

Costs are divided into three categories:

1. Category A (U.S. Navy ship's operating costs) incorporates only those U.S. Navy ships assigned to TF-65. Not included in this category are the various replenishment ships that were at the scene for 1 or 2 days duration.

Ships were considered to be assigned to one of these units as soon as they were underway for the Palomares or Rota operating area.

The total cost figure for each ship is based on its daily operating cost times the number of days assigned to the salvage operation. The operating cost for each ship encompassed seven major direct cost areas. Support personnel and training were considered indirect costs.

Not included in the above costs are the numerous non-ship oriented units and supernumerary personnel who were dispatched to Palomares. These included part of EOD Unit Two; UDT-22; SEALAB divers; divers and other personnel from NAVSTA Rota and elsewhere in the Mediterranean area, ServLants LORAC Support Team and extra divers from Servron 8; boats of ACU-TWO; and very many officers and Navy civilians dispatched to assist CTF-65 as staff members and consultants.

Category A costs (U.S. Navy ships' statistical operating costs) have been tabulated and summarized. However, only the summary figures are presented herein because of the classified nature of the information. The cost figures supplied do not include Navy administrative costs in Washington and in laboratories or various staffs in CONUS. Also, costs are not included for communication services, or for Navy, or Military associated with the removal of the first three weapons, debris, and the contaminated soil.

2. Category B incorporates those costs incurred by Navy Commands and Activities which are directly chargeable to the salvage operation. The total costs for Category B totaled $3,026,666. Five of the thirteen Navy Command/Activities furnishing assistance, are listed below with cost breakdowns, followed by a summary of <u>all</u> Category B costs (Table 3-2).

a. NAVOCEANO. NAVOCEANO's participation in AIRCRAFT SALVOPS MED fell into the following four categories:

(1) Producing of an interim chart by hydrographic survey using the USNS DUTTON as a survey ship.

(2) Furnishing an analysis and report of currents and bottom bearing characteristics.

(3) The deployment of one Naval Coordinator and four Geodetic Engineers to insure proper set-up of Decca-Hi-Fix system and the formation of plotting charts for the purpose of relocating contacts.

(4) The fourth category concerned the efforts made by NAVOCEANO in the Washington area and included the configuration of special displays, charts and models. The total costs were $108,007.

TABLE 3-2

SPECIAL NAVY COMMANDS

Navy Command or Activity	Cost
CINCUSNAVEUR	$ 25,725
CINCLANTFLT	170,197
Deep Submergence	1,085,000
Office of Naval Research	1,106,200
NAVOCEANO	108,007*
NOTS Pasadena	426,388*
MDL Panama City	7,600
NAVSCHOOL Deep Sea Divers	6,552
SUB. MED. CENTER, New London	1,893
COMSERVLANT	51,000
BUWEPS	351
OPNAV	375*
INDMAN 12	37,380*
Total	$3,026,666

* Not final costs.

Attempts to determine the true final cost were only partially successful. The final costs for NOTS Pasadena were furnished by NWC China Lake and are included. Records from the other activities were not readily available. Since the percentage change is believed to have been minor, the issue was not pursued further.

b. NOTS (Naval Ordnance Test Station, Pasadena, California). The following is a summary of the equipment and personnel furnished by NOTS of Pasadena, California for use in AIRCRAFT SALVOPS MED.

(1) Two underwater TV systems, consisting of cameras, lighting equipment, and TV monitors to detect and identify contacts.

(2) CURV - A cable controlled underwater research vehicle; procured by NOTS and redesigned by their Missile Branch.

(3) DEEP JEEP - A tethered vehicle developed by NOTS for undersea research and exploration with a personnel capacity of two. The total costs were $426,388.

c. SPECIAL PROJECTS OFFICE. The following equipment and services are directly chargeable to the Special Projects Office and figures were obtained directly from same:

USNS DUTTON		$348,600.00
ALUMINAUT and PRIVATEER		450,420.00
Straza Industry (Sonar equipment)		1,213.00
Sperry (Navigation equipment)		13,309.00
Westinghouse (Sonar for USNS MIZAR)		177,589.00
Travel		5,000.00
	Total	$996,131.00

d. OFFICE OF NAVAL RESEARCH. The office of Naval Research provided the following:

ALVIN		$525,475.00
USNS MIZAR		550,725.00
Navigational Bottom Markers		30,000.00
	Total	$1,106,200.00

The total for the above was obtained from the office of SUPSALV.

e. NAVSCHOOL Deep Sea Divers provided:

Swimmers equipment		$3,289.00
Heli/oxy Gas		2,910.00
Baralyme		353.00
	Total	$6,552.00

3. Category C incorporates those civilian contractor and sub-contractor costs directly chargeable to AIRCRAFT SALVOPS MED. The total civilian contractual price of $2, 120, 000 was for procurement or lease of services and/or equipment.

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SECTION 4

PALOMARES AND INTERNATIONAL RELATIONS

GENERAL:

It is inconceivable that an incident such as that at Palomares would be ignored or later forgotten by governments or their people. In times of war, acceptable risks are expected. In times of peace, however, otherwise negligible risks become potential disasters. As a risk is transformed into reality, as occurred at Palomares and later at Thule, governments and peoples take a new look at the risk and ask themselves if a previously acceptable risk is now less acceptable, or unacceptable. These reevaluations do impact on military operations and defense preparedness.

There were few precedents to follow in the handling of relations for this accident. It was the first time that an incident involving aircraft had resulted in nuclear contamination of the soil of a nation friendly to the United States. Unlike more commonplace happenings, a State Department-to-Foreign Office note of apology for the contamination was considered inadequate. In addition, loss or damage to weapons, particularly nuclear weapons, provides an abundance of material for propaganda campaigns which are motivated by innumerable and often conflicting causes.

Stationing of foreign troops in one's country in peacetime inevitably provides fuel for the fire kindled by anti-government elements. It is distasteful to political groups, irrespective of their political persuasions. The situation in Spain in January of 1966 was a perfect example of this reaction. Anti-government groups seized upon the accident, and its aftermath, as examples of the Spanish government's failure to safeguard its citizens, and as a glimpse of future problems should the government's policies with respect to U.S. bases remain unchanged. Much of the reaction represented reasonable nationalism. Most of it represented the work of irrational zealots who would not hesitate to use propaganda in its most insidious form.

The reaction of the Government of Spain was certainly reasonable under the circumstances and generally took two forms. The first was a fairly rapid move to restrict similar U.S. flights in the future. The second was to attempt to provide as much information as possible to the general public. Aside from its desire to placate its own citizenry, Spain also had to consider the reaction of international tourists to the contamination. Some of the international tourists to the contamination. Some of the international information media characterized the Spanish Mediterranean as a dangerous wasteland as a result of the accident.

RELATIONS WITH THE SPANISH:

U.S./Spanish relations concerning on-site operations at Palomares, public information policy, and claims activities are covered in other sections of this report. It is sufficient here to indicate that the long term impact of the accident on U.S./Spanish relations is probably small. The later renegotiations held in 1968 for our use of bases in Spain were somewhat more difficult. There is little doubt that Palomares was used as a lever by the Spanish. The resulting agreements, however, probably represented normal growth and could probably have been forecast had the accident not occurred.

RELATIONS WITH THE SOVIET UNION:

At the time of the accident, a disarmament conference was in progress in Geneva. The Soviet representative took advantage of the accident stating that, "only a fortunate stroke of luck saved the Spanish population of the area from catastrophe." An Aide Memoire was passed to the U.S. Ambassador in Moscow on 16 February. It charged that the accident constituted a violation of the Limited Test Ban Treaty of 1963, and extended the implications of the accident to the world in general. The basis of the charge was that the purpose of the treaty was "to put an end to contamination of man's environment by radioactive substances." The United States was also charged with violations of international law pertaining to the open sea and with operations in opposition to the 1958 Open Sea Convention. The note finally called for the United States to cease all nuclear armed flights outside the limits of its own national borders. The charges were rejected.

The same line was the subject of a call in March for the United Nations to act against U.S. nuclear flights. Later, when the fourth bomb was located, the Soviet Union called for an international commission to verify the recovery of the weapon. The United States, of course, was not amenable to such a proposal for security reasons.

RELATIONS WITH GREAT BRITIAN:

On 9 February, the British Minister of State for Foreign Affairs answered a query concerning radiation dangers in Spain for British tourists. The Minister answered:

> "I am advised that there is no indication whatever that the recent aircraft accident over the coast of Spain involving an unarmed nuclear device has resulted in any present or prospective risk to holiday makers on the neighboring coast or sailing in nearby water. British citizens who seek information will therefore be advised in these terms."

SECTION 5

CLAIMS ACTIVITIES

INTRODUCTION:

When an accident occurs, the parties involved have several methods of settling responsibility and pecuniary liability. A first course would be by gentlemen's agreement. This system provides satisfaction and involves the least administrative burden on the participants. At the other end of the scale of peaceful settlement is the court suit, involved and lengthy procedure. The claims system employed at Palomares falls somewhere in between. The procedure involved a relatively informal statement of circumstances by the claimant and a non-judicial investigation by an administrative agent of the U.S. Government. On a finding by the U.S. agent that the claim was justified, a settlement could be made on the spot.

Although the accident at Palomares did not involve the injury or death of any foreign national, there was never any question that claims would arise in its aftermath. Lives were disrupted and free access to property was denied. The fact that the participants in claims activities were the government of one nation and the citizens of another did not lessen the responsibility of the offending party. It did, however, make settlement more difficult.

LEGAL BACKGROUND FOR PAYMENT OF CLAIMS:

The first foreign claims legislation was enacted in April 1918 to provide for damages suffered by inhabitants of friendly European nations from American troop activities.* This act remained in effect through the beginning of World War II when provision was made - for duration of the national emergency** - for payments to $1000 for such damages. In April 1943*** the Act of 1918 was repealed and replaced by new rules with the monetary limit for claims which could be handled locally being raised to $5000, with amounts over that going to Congress for approval. At the same time the restrictive "national emergency" term was removed providing for payment of damages resulting from "non-combat activities." These were considered as "authorized activities having little parallel in civilian pursuits, and which historically have been considered as furnishing a proper basis for the payment of claims." This included the operation of aircraft.**** A claim was "cognizable under the Foreign Claims Act if the damage, loss, personal injury or death was proximately caused by an act or omission of Air Force military or civilian personnel or is otherwise incident to

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* 18 April 1918, 5 U.S.C. 210; 1940 ed.

** Declared by President Roosevelt on 27 May 1941.

*** 22 April 1943, 31 U.S.C. 224d, 1946 ed.

**** Included were "... maneuvers and special field exercises; practice firing of heavy guns; practice bombing; operation of aircraft, including the generation of sonic booms; use of balloons, animals, or instrumentalities having latent mechanical defects; and movement of combat vehicles or other equipment designed especially for military use."

Air Force non-combat activities." The claims had to arise outside the United States, its territories, Commonwealth, and possessions. Payable claims were authorized in the cases of:

> (1) Damage to or loss of real property of any foreign country or of any political subdivision or inhabitant of a foreign country, including damage or loss incident to use and occupancy...
>
> (2) Damage to or loss of personal property of any foreign country or of any political subdivision or inhabitant of a foreign country...

Consideration of claims and payment was by a Foreign Claims Commission (FCC) which could be activated if needed. In Spain such a Commission was in existence, Foreign Claims Commission 21 (FCC-21), in connection with the occupancy by American forces of installations under the Spanish-American agreement of 1953, as amended in 1963. This three-man FCC-21 was permitted to settle claims up to $15,000 as long as the settlement did not exceed $5,000. Awards in excess of that $5,000 up to $15,000 had to be approved by the Staff Judge Advocate of USAFE. Claims in excess of $15,000 could be settled in an amount up to $15,000 by the Secretary of the Air Force or his designee, and claims for payment in excess of $15,000 could be certified to the Congress. In the cases of potential claimants, when an aircraft accident such as this occurred, U.S. Air Force, i.e., the Judge Advocate General (JAG), could authorize emergency payments up to $1,000. Payment of claims was to be in the currency of the country where the accident occurred, or where the claimant resided.

In 1963, the DOD outlined the principle of "Single Service Assignment of Responsibility for Processing of Claims," and divided the work into areas to be handled by the three services.* Most of the European and mid-eastern countries were assigned to U.S. Air Force, and included Spain.** Cross-servicing for claims was provided for by the interested service investigating and then filing the claim with the responsible service for settlement.

Spanish Laws on Claims:

Spanish law provided for payment of damages based on whether the damaged items were considered as movables or immovables. The latter were classed as anything either attached to the land - such as buildings, plants, trees*** - while the movables were those items being

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* DOD Directive 5515.8, "Single Service Assignment of Responsibility for Processing of Claims," 4 Dec 63.

** Air Force had responsibility for Canada, Denmark, Greece, India, Japan, Libya, Luxembourg, Nepal, Netherlands, Norway, Pakistan, Saudi Arabia, Spain, Turkey, United Kingdom. Navy: Australia, Iceland, Italy, Portugal, and certain foreign ports. Army: Belgium, Democratic Republic of Congo, Dominican Republic, Ethiopia, France, The Federal Republic of Germany, Iran, Korea, Liberia, Mali, Senegal, Republic of Vietnam.

*** A brief resume of the immovable items was in Article 334, Civil Code, which names lands, trees, plants, pending fruits, livestock stables, pigeon houses, beehives, fishpools, if maintained with the idea of being permanent. This same applied to the tools for the farm and fertilizers placed already on the land where they were going to be used.

capable of being moved from one place to another without detriment to the immovable object. While damages could be paid in both cases the criteria was slightly different. For movables a fair price was to be paid as determined by both parties; however, if such an agreement could not be reached then an evaluation tribunal was to determine the actual price. For immovables the owner was entitled to payment for damages and loss of rents, with payment not to exceed the price of the property. Here a 5 percent factor came into being, which was mentioned several times in dealings with the Spanish. This was contained in what was known as "Article 47," where "in all cases of expropriation, the private person will be paid, besides the fair price as determined ... a price of attachment of 5%." Since expropriation was not a part of the claims procedure in the Palomares affair, this 5 percent addition did not apply, and was not allowed.

Provision for claiming damages in the event of involvement with some type of nuclear energy was contained in an article of the Law of Nuclear Energy, of 29 April 1964. This provided for claims being made up to 20 years after the incident, in some cases, and if the damages increased after that time limit, another claim could be made providing no limitation had been placed by competent authorities.

To establish the legal background of the accident in the eyes of the Spanish, and to provide a basis on which claims could be filed for damages, a Causa was issued by the Air Ministry from the Escuela Elemental de Pilotes de Granada (Pilots' Elementary School of Granada). In the Causa, the occurrence of the accident was outlined, the crew listed, both survivors and deceased, and it was stated that:

> "... From the facts, it does not appear that the action of the members of the crew was negligent or was due to lack of experience. It does not appear either that they failed to observe rules that they were supposed to comply with in order to prevent the accident. In consequence, it does not seem that there is evidence that they have committed any offense, and, in accordance with Article 723 of the Code of Military Justice, it is proper to declare the provisional suspension of the proceedings."

The issuing of this Causa was normal in any accident, whether it be automobile or aircraft. It provided for the appointment of a military investigating officer, named Major Sebastian Delgado Palomares as the investigating judge for the military, and stated that the estimate of damages totalled 28,417,484 pesetas ($473,624.73 at 60 pesetas per $1.00). It also stated that:

> "... It has been proved that important damages have been caused because of the said accident ... (and) the private parties affected should be informed of the legal actions to which they are entitled ..."

The above document was signed on 21 April. Known as Case #2-66, this constituted the legal basis for citizens to claim damages and was approved by the Judge Advocate of the Spanish Air Force on 30 April, and signed on 13 May, with transmittal to the American Embassy at Madrid.

Spanish-American Agreements:

Article XVIII of the Technical Agreement, signed 26 September 1953, provided that claims of "inhabitants of Spanish territory for acts of omissions by members of the United States may be settled under the applicable laws of the United States," as may be seen in paragraph 4 of the Article which is quoted in full on the following page. Supplementing this was recognition of the Spanish 1964 law on claims for injury or accidents due to nuclear incidents. This was referred to in a DOD/State message which discussed, among other things, claims which could not be handled through the Foreign Claims Act. In event any future meritorious claims should arise as a result of this accident which cannot be legally paid under the Foreign Claims Act, they will be handled through diplomatic channels in accordance with paragraph 3 of Note No. 82 of 17 July 1964. This exchange of notes contemplates "recognition" of the Spanish Nuclear Energy Law 25/64 of Limitations of 10 and 20 years in the case of immediate and deferred damage respectively.

Exceptions for Palomares:

In the claims area, as in just about every other situation in this KC-135/B-52 accident, the word "unusual" applied. The circumstances dictated exceptions to normal procedures, particularly since relations with the host country were somewhat disturbed, and since the usual approving office was several thousand miles away which could limit prompt action on larger claims.

Since the aircraft debris scattered along a 2-mile line, along with two low-order explosions of the HE of nuclear weapons, it was realized that a large number of claims might be submitted, and that some immediate help to the local residents could be required. The 16AF Judge Advocate, Col. James L. Kilgore, phoned the Claims Division, Washington, on this matter. Verbal authority was given to make emergency payments up to $1,000.00 on potential claims for damage or injury. While making these emergency payments the FCC was told to assure claimants that such compensation would not bar them from making claims for larger amounts when actual damage costs would become known.

This delegation of authority was followed by a second, a week later, after another conversation and confirming wire. At that time FCC-21 was "authorized to settle claims arising from this incident up to statutory limit of $15,000.00." Amounts above that were still reserved for U.S. Air Force action to Congress. At the same time, the U.S. Air Force said that they desired the Claims Commission in Spain to work closely with the Spanish authorities and to "use claims settlement authority to fullest extent possible to settle claims expeditiously."

In general, payment was authorized to "any local national who can establish property damage or personal injury of any nature which can be attributed to activities of USAF or its agents." Excluded from such payments were the pay of civilian workers employed in the search activities; however, if radiation exposure became a problem in their work, then a claim could be considered as cognizable. No cases of this type arose at Palomares.

EXTRACT, TECHNICAL AGREEMENT

ARTICLE XVIII

1. Member of the United States Forces shall not be subject to the civil jurisdiction of Spanish courts or authorities for acts or omissions arising out of the performance of their official duties. A certificate from the United States military authorities attesting the status in this regard of a member of the United States Forces shall be considered conclusive by Spanish authority.

2. Each Government waives all its claims against the other for damage to any property in Spanish territory owned or utilized by it if such damage (a) was caused by a member of the armed forces or civilian components thereof of the other Government while engaged in the performance of his official duties, or (b) arise from the use of any vehicles, vessel or aircraft owned or utilized by the other Government by its armed forces or any employee of such Government. Each Government waives claims for maritime or aircraft salvage against the other provided that the vessel or aircraft or cargo salvaged was owned by the other Government or being used by its armed forces at the time the incident occurred.

3. Each Government waives all its claims against the other for injury or death suffered by any member of its armed forces or civilian components thereof, while such member was engaged in the performance of his official duties.

4. Claims of inhabitants of Spanish territory for acts or omissions by member of the United States Forces may be settled under the applicable laws of the United States. Any settlement effected thereunder shall operate as a complete release as to both the United States and the individual concerned from ulterior responsibility for damages arising out of such acts or omission.

5. The undertaking of a suit in a Spanish civil court against members of the United States Forces on the occasion of damages chargeable to any act or omission of said personnel, shall operate as a waiver of any right that may exist in the Government of Spain or persons resident therein to administrative relief from the Government of the United States for claims arising out of such act or omission, including the procedure referred to in paragraph 4 above.

CLAIMS OFFICE:

A member of the staff of the 16AF, Office of the Judge Advocate, went with the Disaster Control Team to Palomares on 17 January. Three days later a member of the Foreign Claims Commission went to Palomares, followed by a second member on 26 January. These three were augmented by another officer, a Spanish civilian attorney and five airmen, so that until about mid-March the strength of the claims office numbered ten. These personnel came from the 16AF, with the exception of one officer from JUSMG who reported on 1 February, and one NCO from Vandenburg who was sent to assist. Locally, the son of the mayor of Palomares was hired and proved to be a valuable addition. He knew all the local residents, the location of property and its owners, and had good contacts with all the local officials. By the end of April the work force had been reduced to one officer and two airmen, and on 28 May the office officially closed at Palomares, although the mayor's son continued on the job about one day a week to handle letters to and from the office at Torrejon.

At the beginning, two tents at Camp Wilson were used for the claims function. These were, of course, far from ideal, particularly with regard to conducting interviews with claimants, as some claimants were both voluble and noisy at times. Since it was really more desirable to have the claims office closer to the people it was to serve, an inquiry was made as to the possibility of renting a building or office space in Palomares. The local banker had a house that was not in use and the U.S. Air Force used it, without payment of rent, on the provision of turning it back to the owner in the same condition in which it was received. The office occupied this space from 4 March until 28 May 1966.

EMERGENCY PAYMENTS:

The message was received on 19 January authorizing emergency payments up to $1,000.00 with the Washington Claims Division stating that such payments were authorized to those who could "establish property damage or personal injury of any nature which can be attributed to activities of USAF or its agents."* However, it was not until 24 January that the first actual payment was made. This one was for $66.73, and was made to the local milkman who had not been able to sell milk due to the fear of contamination, and without that income he could not buy cattle feed. By a week later, on 31 January, 74 payments had been made for a total of $3,257.48. The last emergency payments were made on 1 April to 38 Villaricos fishermen in the amount of $951.14. This brought the total number to 222. Of these, 213 were recovered when regular claims were filed ($13,990.14). Seven were not recovered since no further claim was made ($275.64), and two were included in claims the settlement of which was not yet accepted by the calimants in September 1966 ($421.25).

* The Claims Division stated that pay of civilian workers engaged in search operations could not be paid from claims funds, unless they filed claims for radiation exposure in which case special approval authority would have to be obtained.

In considering the need for emergency assistance, one item was the requirement to buy animal feed since entry to the normal feeding areas was not possible in cases where clean-up activities were in progress. Lost wages for field hands and fishermen were compensated for by this method until actual lost time could be established and the rate of payment calculated. About 10 days after the accident when weekly wages were not forthcoming due to the ban on entry to the fields, clean-up activities, or inability to market fish, there was particular requirement for such payments. Money required to pay bank loans, or to provide for new plantings were also considered as meriting this assistance since people had little in savings as their margin of profit was very small. The peseta value distribution of emergency payments is indicated in Table 5-1.

OFFICE OPERATION:

While the actual adjudication and payment of the claims was primarily an American responsibility, Major Palomares, as Judge of the Court of Instruction for this area, was at his request the focal point to which the Spanish first reported. When appearing before him they were advised of the penalties for perjury, and were placed under oath. He then determined the validity of the claims, and discouraged those he considered as unreasonable or as unconnected with this disaster. Upon completion of the interview the claimants were given a slip of paper showing that they had visited him; without that the claims personnel would not consider a claim.

Proceeding then to the claims office, the claimants* were given the required forms to fill out. When these forms had been completed, an interview was conducted to determine (1) any additional facts that would help in the claim preparation, and (2) the claimant's possible need for an emergency payment.

Within the office the documents and claims generated from the interviews were picked up several times a day and taken to translators in the administrative section. At that time they were logged in and the claims file started. That file was reviewed by one of the claims officers for determination if further investigation was required. If additional investigation was required, it was then done and the file later returned to the officer. Upon completion of that, a breakdown of the items claimed was made, the recommendations for each listed, and the file went to one of the three commission members. After their review, a brief discussion was held with another member of the commission, then the final figures were determined and

* The JAG's summary of the Palomares incident explained the system of names used in Spain - which complicated identifying family relationships: A Spaniard's proper name consists of his given name(s), followed by his father's family name, followed in turn by his mother's family name. Often the given name is itself a family name. Thus there were "Blas Alarcon Navarro, "Alarcon Navarro Blas, and "Navarro Blas Alarcon". Fathers and sons (grandfathers too) could have the same names, and these sometimes distinguished themselves by adding "Mayor" or "Menor" to their signature. Sometimes they didn't. Among our claimants were twelve named "Navarro Flores" and four called "Francisco Sabiote Flores". There was also one "Antonio Alias Alias."

TABLE 5-1

DISTRIBUTION OF PESETA PAYMENTS
Palomares, Spain
24 January - 1 April 1966

Amount	Number
0 - 4,000	188
4,001 - 8,000	16
8,001 - 12,000	5
12,001 - 16,000	1
16,001 - 20,000	2
20,001 - 24,000	0
24,001 - 28,000	1
28,001 - 32,000	0
32,001 - 36,000	0
36,001 - 40,000	0
40,001 - 44,000	0
44,001 - 48,000	1
48,001 - 52,000	1
42,001 - 56,000	2
56,001 - 60,000	3

the file then went to the administrative section for preparation of the necessary forms. Then, the claimant could be informed that all was complete and payment was made either by check or cash at the same time that the acceptance agreement was signed. Notification was made either personally, or through a list posted in the local barbershop. When payment was made by check the local bank cashed it, which required payment of a 1 percent charge, and

that amount was included in the computations of the payment due. To simplify preparations of letters to claimants, 16 standard paragraphs, in both English and Spanish, were prepared. Some of these were:

> The Foreign Claims Commission has determined that the above amount includes adequate compensation for loss of earnings in this case.
>
> The most recent information received from the official appraisers of the Ministry of Agriculture which have been used in the determination of damages indicates that the fair amount of total damages is not higher than the amount approved by the claims commission.

While the above description simplifies the claims procedures, and does not appear to be a difficult or time consuming task, some data on the activities may give a different idea of the work load. One claims officer at the scene stated that:

> ... From the date of the accident to the middle of February, the average rate of interviews was 10 per day. By the end of that month the rate had more than doubled; and during the first few days of March the rate decreased to a level of about 16 interviews per day. The actual number of daily interviews, during this period varied considerably from a low, on Sundays and Spanish holidays, of 0 to less than 10, to a high of 66 on one day in February. By the time the office closed in May, the more than 500 claimants had visited the claims office on more than 2000 occasions.

CLAIMS PROCEEDINGS:

A week after the accident, claims personnel estimated that in one area of 35 acres the cost of the crops being destroyed would be about $14,500.00. In addition, it was anticipated that a claim of about $3,000.00 would be presented by the fishermen who rescued the survivors and who had damaged their boat when docking. But by the time five more days had passed, on 31 January, the estimate had spiralled to a possible 600 claims for about $100,000.00. By that date some idea of the problem was developing since 70 emergency payments had been made totalling $35,000.00.

The following day a summary of some of the problems involved was made. It was believed that the claims would be those normal in any multiple aircraft accident, but in addition, this one was complicated by psychological factors that stemmed from the contamination problem. The JEN had told the people to stay out of the fields, the town of Palomares was "off limits" both for entry and departure, and all was confusion. The people were not told the reasons for this, but the press and radio - denied authentic information - had many words to say on the subject. Thus, on Saturday after the accident, 22 January, buyers - including those from out of town - refused to buy the local products, considering that all product of the land and the sea were poisoned and inedible. During the days from 22 to 31 January the market recovered somewhat, but when one of the claims officers checked the markets of

the village of Vera he found that there was about a 50 percent drop in both volume and price in the area; however, some out of town buyers were returning. Also, some confidence was being built up in the local populace as the JEN had fairly well designated the fields to be opened for working and forage, although in many cases the people were not told, or ordered, directly to return to their fields and time was lost by this fact.

Before January ended some complaints were heard that claims were not being paid, and Maj Gen Wilson discussed this with the mayor who said that people had been advised by the Spanish agriculture representative not to file claims at that time, although the Spanish were satisfied with established American claims procedures. It may be that this advice stemmed from the fact that an official survey was underway which would provide firm costs on which to base claims. On the evening of 31 January, a meeting of the people was held in the local theatre with Maj Gen Wilson and Brig Gen Montel addressing the citizens. They explained the situation as far as possible, and how the claims process would work. These talks eased the tension somewhat. By that time it was also known that surveys were underway to establish a basis for payment for damages incurred both by crop destruction and through the search activities.

The next problem arose from the wording of the release that claimants would sign upon accepting money from the United States when the claims were completed. They disagreed with the "finality" clause as they felt that the word final in "liquidacion final de mi reclamacion contra el Gobierno de los Estados Unidos," would prevent collection of full damages since at that time, the early days of February, the extent of the claims could not be known. The Spanish and English versions of this form may be seen on the following page.

As a result of this feeling that anyone accepting such "final" settlement at that time would be the object of some degree of discrimination, about 3 February the Spanish authorities told potential claimants not to sign the acceptance forms. This matter was then discussed at higher levels, in both Spain and the United States. Maj Gen Donovan, Chief of JUSMG/MAAG, met with General Eduardo Prado Castro, Vice Chief of the High General Staff, on 12 February concerning the wording of the form. On 18 February he sent General Castro a letter telling him that:

> The claims forms now in use meet the requirements prescribed by the Foreign Claims Act ...
>
> ... payment of a claim is considered by the United States Government as settlement only for claimed damages or injuries known at the time of filing.
>
> Damages or injuries, even though arising from the same incident, which subsequently accrue and were unknown at the time of filing of the first claim may be made on the basis of a new claim, which, if found meritorious and otherwise meets the requirements of the Foreign Claims Act, will be paid...

(Translation)

ACCEPTANCE AGREEMENT

By these presents, I, ______________________________, Spanish National Identification Card #______________________________, residing in Palomares, Cuevas de Almanzora (Almeria), Spain, accept the sum of ______________________________(Pesetas) ($) in full satisfaction and final settlement of my claim against the United States, for all damages, resulting from an aircraft accident occurring on 17 January 1966 in Palomares, Cuevas de Almanzora (Almeria), Spain, to my share of the crops in

Poligon No____________, Plot No ________________, Palomares, Spain, and I renounce all extent or future causes or rights of action that I have accrued or may accrue to me in relation to the above mentioned crops.

Signed in Palomares, Cuevas de Almanzora (Almeria), Spain, this ________ day of ____________, 1966.

Signed:

ACUERDO DE LIQUIDACION

Por el presente documento, yo, ____, con documento nacional de identidad num. ____, domicilio en Palomares, Cuevas de Almanzora (Almeria), Espana acepto la cantidad de

____

(Pesetas) ($) en concepto de indemnizacion y liquidacion final de mi reclamacion contra el Govierno de los Estados Unidos y empleados o miembros de dicho Gobierno, por la totalidad de los danos y prejuicios, a consecuencia del accidente aereo ocurrido el 17 de Enero de 1966 on Palomares, Cuevas de Almanzora (Almeria), Espana, a mi parte de las cosechas en Poligono Num. __________, Parcela Num. _________, Palomares, Espana, renunciando al ejercicio de cualesquiera acciones que me puedan corresponder contra dicho Gobierno en relacion a las cosechas indicadas.

En Palomares, Cuevas de Almanzora (Almeria), Espana, a _________________ de ____________________ 1966.

Firmado: ___________________________

AFE/66- /FS

... the two year statute of limitations under the Foreign Claims Act would not begin to run until the date the damages or injuries became known...

... (other claims) will be handled through diplomatic channels...

This letter evidently convinced the Spanish that the "finality" clause was not really final, as long as the claims were legitimate, and on 24 February the ban against signing the acceptance document was lifted. Brig Gen Montel used this letter also to get the message to the claimants, and it was translated into Spanish and handed out to them. Maj Gen Wilson told U.S. Air Force that he had heard of criticism in delaying of payments. He said he could not understand this since it had been the GOS (Government of Spain) that had imposed the ban and thus set up a three weeks delay period in payment of final claims, although 140 emergency payments had been processed for $11,814.52 by that time. It became a proven fact that it was possible to reopen claims cases since there were 120 amendments to original claims, with 92 having 1, 25 having 2, and 3 having 3 amendments.

Establishing Values:

The Americans coordinated closely with the Spanish authorities to determine the amounts that could be paid for wages, market losses, animals, and crop damages.

For crops, which were involved in 94 percent of the total claims paid, there were four estimates of loss computed. Two of these were not considered by the Spanish as official, while the remaining two were prepared at their direction. The Claims Office estimated that crops from 625 acres of farmland were involved, with 340 acres of that being within the contamination zone. Distribution of the four principal crops was:* grain, 10%, alfalfa, 20%, beans, 30%, and tomatoes, 40%. Harvesting was underway for two of the three annual crops, the beans and tomatoes; the grain planted in the preceding fall was not due for harvesting until April or May; the majority of the alfalfa fields were 1 to 2 years old, and were harvested monthly under normal circumstances.

One of the first things that became apparent as a problem area in estimating damages was in obtaining maps sufficiently accurate to plot ownership and show the crops. In Spain the provinces are divided into polygonas, and then into parcelas, and for this area of the country only free-hand drawings of the polygons and parcels were available. When the registry of owners at Cuevas de Almanzora was consulted it was found that entries were as much as 6 years behind, that boundaries of parcels had been changed without being recorded, tenants and sharecroppers were not always listed properly, with many of the working agreements being purely verbal. Digressions from normal recording procedures were particularly true in the cases of transfers from one member of a family to another, and those intra-family shifts were often not readily apparent because of the complete difference in names from one

* Other crops in the area included cucumbers, olives, peas, peppers, potatoes, prickly pears, lettuce, and cabbages.

generation to another. In the event a change of ownership was not registered, the owner was asked to show his notarized title transfer, Escritura, but this did not help much since it did not show either polygon or parcel, but rather listed the surrounding land owners, and those had changed in many cases. Thus, the claims personnel decided that:

> ... the problem was not one of non-owner claimants, but rather of an inability to establish with any certainty that the claimant was the owner-in-fact. Therefore, it was decided to take the calculated risk of paying a nonowner and rely on the presentation of an Escritura or a certificate from the mayor or other person familiar with the area as the ownership, and thereby avoid the probably impossible and time-consuming tasks of tracing ownership from the registered owner. Time proved this to be the right decision, since not one allegation of payment to a non-owner has been raised as of (September).

Utilizing the aerial survey photographs and with much assistance from the mayor's son, it was possible to prepare outline maps with sufficient delineation to permit identifying the parcels, establishing the crops, and to determine to whom the payments should be made. This process involved determining whether the owner worked the land himself, rented it out, or if a share-cropper was involved with either the owner or tenant.

The estimate considered as unofficial by the Spanish was that of the independent appraiser, known as a perito, who was hired by the FCC to appraise damages. Sr. Francisco Gonzalez Navarro started working on Saturday, 22 January, and by 30 January had made estimates for 25 to 30 acres of the crops within the contaminated zone. However, the Spanish experts arrived on the scene and would not permit him to work at the same time they were in the fields, and thus his usefulness in that area was limited. However, he was utilized to provide estimates on crops not appraised otherwise, and to assist in estimates of property damage claims.

The other unofficial estimate, and the one on which many of the claimants based their claims, was prepared by two persons appointed by the mayor of Palomares, Sr. Jose Manuel Fernandez Gonzalez, and was presented to the Americans by a local lawyer on 5 February. This was known as the Board of Neighbors Report, and placed crop damage at $653,906.67. While the list was fairly complete and contained the names of the owners, share-croppers, and tenant farmers, and the general areas where the crops were located, there were various factors in the report that made it extremely difficult to work with. In general, the value factors used for the various crops were not listed, the exact locations of the parcels were not given and 111 contained more than one name. In addition, although it had been prepared at the request of the Palomares mayor, the Spanish governmental authorities did not recognize it as an authentic source document on which to pay claims. Advice was then given to the claimants of the Board of Neighbors Report that individual claims would have to be submitted, and that it was thought to be premature to say that all crops would be totally destroyed.

Six days after the accident, on 23 January, Sr. Manuel Mendizabal Billalba, Chief Engineer of the Department of Agriculture, visited the site at the request of the Minister of Agriculture. The purpose was to personally report the extent of the damages, the kinds of crops and their condition. Then, following the instructions of the military judge, Major Palomares, two appraisers were appointed: Sr. Francisco Alados Vielma and Sr. Isidoro Vertiz Espinar, from the Technical Division, Department of Agriculture, Almeria area, to prepare the estimates from which payments were to made.

The first of two estimates was completed about 5 February and submitted to the FCC-21 on 15 February. The basis for their estimates were contained in an annex to the report:*

Alfalfa: Grown for feed, 12 cuttings per year, when not available must buy feed.

Beans: In first cycle of production, 2 to 12 pesetas a kilo.

Corn: If operations finished by 1 April this can be still planted in time for a good crop.

Grain: Basic feed for livestock; cut green, followed by use of grain and straw; up to 1.80 pesetas a kilo.

Soil: Where removed, to return land to original state for cultivation, requires either refilling or use of manure and mineral fertilizers; about 30,000 pesetas per hectare.

The second agricultural report was given to the FCC on 21 February, and consisted of a general upward revision (Table 5-2). To these two reports were added four annexes. Two concerned payments to certain individuals in which their claims were adjusted due to newly discovered facts, while the other two were general changes.

The first of the two general adjustments was dated 3 March and concerned the price of beans in Spain, and particularly in Palomares. The losses in this area were primarily in two categories, with the first being the inability to harvest the first crop of beans while they were

* The metric system was used for measure, with equivalents being:

Hectaria	=	10,000 square metres - 2.47 acres
Cuerda	=	87 square metres
Area	=	100 square metres
Centiarea	=	1 square metre
Acre	=	4,049 square metres

In addition other measures were used. One was the "fanega" which was a measure of either size or weight. It varied with location. In measurement of size: 3200m^2 in Palomares; 2,096m^2 in Casa Marques Canal; and 1,746m^2 in Nati and La Hoya, was 1 fanega. In the same order, 1 hectaris = 2.86 fanega, 4.91 and 5.71. It was also used as a measure with 1 F = 1.60 bushels. Another measure was <u>mata</u>, which was a weight, with 1 mata = 3 kilogrammes.

TABLE 5-2

AGRONOMIST REPORT, CULTIVATION, PALOMARES, SPAIN

5 - 21 February 1966

Product	Area (Hectarias)	Peseta Price Per Hectaria	Peseta Value of Cultivation
Out of Zone - 21 February			
Alfalfa	16.8850	25,534	431,150
Beans*	49.5100	23,186	1,147,950
Grain	148.8500	1,946	289,810
Tomatoes**	94.3100	90,420	8,527.600
Vegetable Greens	40.6100	81,720	49,850
In Zone - 5 February			
Alfalfa	11.3000	151,800	1,716,000
Beans	33.7600	85,031	2,870,650
Cabbage	0.0100	350,000	3,500
Cucumbers & Peppers	0.0100	400,000	4,000
Lettuce	0.1000	120,000	1,200
Grain	53.8400	14,750	794,179
Peas	1.200	80,000	96,000
Tomatoes	68.750	109,960	7,560,371

* Beans - 2.32 pts/sq m.
** Tomatoes - 9.04 pts/sq m.

PRIVACY ACT MATERIAL REMOVED

still at the proper stage for picking, and the second due to the loss of growth resulting from the inability to irrigate and care for the plants. The first value placed on this type of damage, for each 10,000 square metres of plantings, was 23,186 pesetas; but a "new consideration" gave a value based on the fact that a kilogram of beans in Palomares was 3.50 pesetas as against a 6.75 average for some other areas. Thus, the figure of 23,186 pesetas was lowered to 21,250 pesetas. Since 495,000 square metres were concerned, this gave a value of 10,518,750 pesetas for the bean crop, or $175,312.50 in the second zone.

The first of the two specific annexes was issued on 19 February and increased the amount due from 89,027 pesetas to 237,027 pesetas. This was due to recalculation of the area of sanded tomatoes and peppers in which the ground has been plowed thus destroying this special preparation for early crops. This was part of payment which finally totalled 583,354 pesetas.* The second adjustment was on 31 March for , and changed the payment due him from 82,800 pesetas to 144,900 pesetas. case is fully discussed in this chapter as a representative case.

While this was going on, it was considered desirable to determine how the agronomists arrived at their figures, and on 2 March members of the claims office met with them. In brief, their decisions were based on the following:

In-Zone estimates made on basis of total destruction of the crops.

Out-Zone estimates on basis of actual losses except for:

1. Tomatoes: based on total destruction as tomato season was almost over; if tomatoes were sold after the estimate was made, the amount of the sale should be deducted.

2. Beans: inability to irrigate and pick, and future sales effected, and any sales made after the estimate should not be deducted. The estimate should be increased, figure to be furnished, since original estimate was based on 6 pesetas sale price, but are selling for 3-1/2 pesetas, and increase required to compensate.

3. Alfalfa crops showed disparity between estimates, and the Neighbors' estimate was based on total destruction both in- and out-zone, where the agronomist was based on total (in-zone), and actual (out-zone) as applicable.

4. Animal feed requirements: recommended payment for alfalfa increased by one-half since feed had to be purchased, which is high in price.

5. Potatoes: seed potatoes expensive; if not planted in February cannot be planted now.

6. Corn: can still be planted this time of year.

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was paid one emergency claim on 28 January, 1,800 pesetas; a second on 31 January for 12,000 pesetas. The final claim paid on 22 April was 569,354 pesetas, bringing the total of 583,354 pesetas.

7. Watermelons: plantable until 15 March, claims on inability to plant before that date invalid.

On 12 March the labor union, Sindical del Movimiento, Hermandad Sindical Comarcal de Labradores y Ganaderos, of Almeria, submitted to the agronomists, a letter on the costs of growing things in this area, and they were somewhat above the agricultural department estimate:

1. Alfalfa: value of one hectare of land planted, 250,000 pesetas;

2. Beans: value of one hectare of land planted and irrigated, 100,000 pesetas;

3. Tomatoes: normally 25,000 plants, with production of 2 to 4 kilos per plant, price in this area from 10 to 15 pesetas per kilo; late production due to electrical transformer outage; not possible to estimate cost per hectare.

This was followed 4 days later by a group of land owners calling on Ambassador Duke to protest the claims payments. Maj Gen Wilson reported to General Ryan at SAC that some allegations were made about the claims activities. A possibility existed that either individuals or an organization may ask for resolution by the International Court at the Hague. In view of this, Maj Gen Donovan and Brig Gen Montel met on the scene on 17 March to gain first hand knowledge. At this meeting Brig Gen Montel was convinced that to expedite claims GOS appraisals must be established and remain fixed and that GOS officials should assure land owners and their lawyers that adjudication of damages was fair. Both generals met with land owners on 18 March. An agreement was reached wherein official in-zone estimates were increased 26.5% for tomatoes, 15% for alfalfa and beans. Outside the zone all crops were increased 26.5%. This appeared to be more satisfactory, although it required considerable recomputation of previously processed claims.

An annex was issued to cover these changes. Included was the statement that there was some possibility of error in both in- and out-zone estimates due to the fact that the urgency of the appraisals did not always permit exact measurement or determination of the condition of the crops, particularly since some were cut prior to observation. The possibility of error in the out-zone was given at 15 percent.

The subject of farm animals was also important, since they were a part of the economy, primarily for local consumption, and for farm work. On 24 February, the JEN surveyed animals for radiation contamination with all results being negative; included were 74 pigs, 4 goats, 3 sheep, and 4 calves. Six weeks later, the JEN issued a statement that the death of animals could not be attributed to the effects of the radiation due to the accident.

Even though this was done the deaths of animals within this area was generally attributed to the radiation and/or the accident. For example, there was a hive of bees that had been downwind for Site #3, and the bees died; however, no connection between the two events could be found. At Las Rozas, cats, rabbits and pigeons had died after eating forage, and pigs

were ill, and since this was within the area of aerial burst they were checked. In that case, it was considered that the death of the rats on the farm could have some cause other than the accident. Claims were submitted for some of these, but no awards were made.

Payments for loss of wages was another claim item. Insofar as farm workers were concerned it was estimated that by 30 days after the accident the normal harvest time would have been ended, and the Commission (FCC) decided that no more than 30 days lost wages would be paid, and that feed payments would cover the same time span since most of the area had been opened to the owners by the end of that time.

On 17 March, the FCC decided to establish a factor on loss of profits for tomatos, beans, and similar produce warehoused in Palomares at 1000 pesetas a day for a maximum of 30 days. There were six warehouses in Palomares.

FISHING CLAIMS:

Fishing was the primary livelihood of persons living in the port towns of Aguilas, Garrucha and Villaricos. With the presence of the U.S. Navy, the rumors on contamination, and the presence of wreckage on the sea bottom, the fishing industry of Villaricos was almost forced out of business during the recovery activity. Thus, special attention had to be given to furnishing emergency payments to these people, as well as to trying to assist in using what fish were caught, or in trying to provide markets for them, and then to return the fishermen and their boats to the sea as quickly as possible.

Fishing areas were not delineated by law or local rules, but primarily by the size of the boat. The particular area where the search was conducted was, in general, a fairly level plain, with few outcroppings that would damage fishing nets. In general, there were three areas used, based on the size of the boats, the weather conditions, and location of the home port:

1. From Carboneras to Mesa de Roldan, large capacity boats.

2. From Mohacar River to level of Palomares, small boats, also used when weather conditions were such that the larger boats could not go to the other side of Carboneras.

3. From Palomares to northeast of Villaricos, both large and small boats; boats from Villaricos use this area.

Three methods of fishing were used in this area, with the most common being arrastre, which required the net to be dragged along the ocean bottom. The other two methods did not require dragging, with one being encirclement (cerca) where the net was pulled through the water without touching the ocean bottom, and the third, artes menores, where a smaller net was used, without dragging. These three types were adapted to the relatively shallow waters of this coast, and the boats utilized were designed and powered to operate by these methods within the fishing area as discussed above. Navigational methods used were more or less

locally devised, and consisted of using landmarks rather than formal navigation methods. Denying entry of the fishermen to their normal areas was of particular importance since they could not just simply go some place else and fish. They were limited by the size and power of their boats. They knew the tides, the ocean floor, and could find their way around without getting lost. Move them to another area and they would be literally "at sea."

There were about 60 boats working in the Garrucha area, employing approximately 300 people in this early part of 1966, and Sr. Antonio Jerez, the harbor master, Garrucha, stated that the number of boats had increased yearly. Weight of fish taken in at the Garrucha port, and the sales price, were given as follows:

SALES PRICES, FISH CATCH, GARRUCHA

Year	17 December - 16 January	17 January - 16 February
1964	1,273,516.10 pesetas	1,335,008.10 pesetas
1965	1,161,993.85 pesetas	1,179,970.45 pesetas
1966	3,635,826.90 pesetas	1,940,932.40 pesetas

Year	Month	Kilograms	Pesetas Sales
1965	January	21,974	1,029,843.40
	February	37,373	1,228,863.10
	October	75,507	1,306,618.15
	November	103,885	2,812,873.30
	December	82,396	3,881,429.15
1966	January	27,878	2,583,487.80
	February	29,163	1,647,658.55

The gross sale of the catch of each boat was called the monte mayor. From this was deducted the expenses of the voyage and a contribution to the fishing syndicate organization. From this latter fund fishermen were entitled to assistance in case of injuries suffered and illness contracted during fishing operations, or for damages to the boats. The rest of the money was divided into two equal parts, with one part going to the owner, while the other,

called the monte menor, was divided among the crew. Each member of the crew received a certain number of shares (partes) according to the importance of his job.*

As elements of the U.S. Navy arrived in these waters the fishing activities were somewhat lessened. At first no ban was placed on fishing boats operating in the search area but on 9 February a large area was placed off-limits to the fishing fleet. This was just about the center of the normal zone of operation for the boats, and particularly affected the smaller vessels. This restriction remained in effect until 1 April when the restricted area was reduced, and then upon recovery of the weapon it was withdrawn. This restriction created problems, and in a letter from Sr. Antonio Jerez, the harbor master of Garrucha, on 14 February, a desire was expressed that an "immediate solution be given to this grave crisis, since as you know the economic life of this town depends exclusively on the fishery business." However, no action could be taken at that time to lift the boundary since frogmen, hard-hat divers, and submersibles were working to recover debris and to search for the bomb. Compounding the problem was the fact that as word spread of the possibility of radioactivity contamination the buyers of fish declined to have anything to do with what fish and crustaceans were brought to the docks. Then came the problem of what to do with a highly perishable product when one had more than one could eat, and no buyers for the remainder. The problem was never entirely solved.

By the end of March the rumble of discontent was beginning to be heard. General Wilson sent a note to General Montel outlining the problem and stating that something had to be done for these people. From Villaricos, about 50 fishermen were claiming damages and from Aguilas, representatives claimed that 800 families had suffered loss of income; however, General Montel said that this was not so as only about three-fourths of the Aguilas boats were unable to work and this many families were not involved. From Garrucha came word of 300 crew members from 60 boats that needed help. General Wilson recommended to JUSMG that the Spanish survey these claims and that either the United States pay directly to the Spanish Government the amount of the assessed damages, or that a list of claimants and the estimated payments due be furnished to the Claims Commission so payment action could be taken. Three days later a member of Brig Gen Montel's staff reported to the claims office that the fishermen of Villaricos were planning a demonstration "because they were in real need and we were taking no action to help them."

* This system was described as "... a net handler might receive one parte, the engineer two partes, and the captain 3 partes. The monte menor is divided by the total number of partes to find the value of each and each man receives the value of his total number of partes. The method which determines the number of partes a man is entitled to is a loose one and may be adjusted upward or downward in accordance with local custom and although the engineer might ordinarily be entitled to 2 partes, the engine of his boat may be in such bad repair requiring more work that he would receive 2 1/2 partes. The matter is determined by the captain since if one man receives more money the others will receive proportionally less."

The JAG, 16AF, discussed the fishing situation in their summary report, prepared late in 1966. Their comments were:

> The fishermen from Aguilas and Garrucha claimed that they had suffered damages because of the reduced market value of their catches and because of the limitations imposed on their fishing grounds. However, the Commission could not readily ascertain any such losses from the official port records, and it requested that the Spanish Government furnish an official survey, comparable to the Agronomists Reports, to authenticate all losses incurred by fishermen and associated activities. A token effort was made in this direction but no report has ever been furnished and no claims from Garrucha or Aguilas have been processed.
>
> Almost all of the able-bodied men from Villaricos worked at Camp Wilson for much of the time we were there, and the wages paid them exceeded what they probably would have realized from fishing for a similar period. Further, most of them had received an emergency payment either during January or February. However, late in March there was much discussion about their claims. The Commission sought to deter this matter but the clamor mounted. Finally, we were advised that the women of Villaricos were organizing an en masse march on our establishment. These ladies were truly fishwives and even the fearless Guardia blanched at the prospect of dealing with their concerted ire. We quickly made another emergency payment to the head of each family in the village. Within the following month, after much discussion, but no marches, all Villaricos claims were finally paid. In this regard, wages earned at Camp Wilson and emergency payments were deducted from awards.

Some attempts had been made to assist in the sale of the fish. For example, Maj Gen Wilson made arrangements for some to be delivered to the Air Academy at San Javier; some was utilized at the camp. But, even though the fishing areas were reduced to less than normal, the catch was of sufficient size that it could not all be used locally. To forestall demonstrations, decision was made to provide emergency payments to the heads of families in need, and 33 payments were made on 31 March for the equivalent of 10 days work at 150 pesetas ($2.50) per day. This temporary assistance calmed the air around Villaricos. Later on 22 April, two weeks after the bomb had been recovered, a formula for payment was worked out; the master-owner and the fish seller could both be paid 150 pesetas per day for a maximum of 60 days to compensate for lost fishing time and the inability to sell what was available.*

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* Master-Owner Payment: a maximum of 150 pesetas per day for 60 days is authorized for the master-owner share. If in applying this formula the computation exceeds the total amount claimed, the amount claimed will be awarded. If the master and the owner are not the same person and the master is claiming on behalf of the owner or any member of the crew we need a general release from all. If the master is claiming only for his share as master he is only entitled to 1/2 the above maximum rate." "Certified fish sellers: a maximum of 150 pesetas per day for 60 days."

The fishing area was restricted on 9 February. This had quite effectively eliminated most of the Villaricos fishermen's area, and with the planned demonstrations of late March, Maj Gen Wilson asked RADM Guest if some of the area could be opened. This was done on 1 April and Brig Gen Montel's office agreed that the new area would satisfy the requirement.

DISAPPROVED CLAIMS:

Ninety-eight claims were disapproved based on factors discussed in the preceding paragraphs. Most of these were for lost wages and loss of profits, and refusal to pay these was based on investigations revealing that they were too remotely connected with the accident to be considered as valid, or that the persons were not listed as local employees. Of the remaining disapproved claims the major portion was concerned with a land devaluation claim at a site 20 miles from Palomares.*

It was apparent that some were filed simply because someone else put in a claim and received some money, particularly in the lost wages or profits categories. Claims for dead animals were turned down, other than for the pig that was killed by an American vehicle since, as stated earlier, no connection between the deaths of animals and the accident could be established by the Spanish authorities.

MARKETING RESTRICTIONS:

The exact date, and by whom, that restrictions were placed on marketing was open to conjecture. Maj Gen Wilson stated in one Memo for the Record that it was on 20 January by the JEN, and included the general Palomares area. Such a ban might have been possible since radiation contamination was known at that time, but the "0" line of contamination was not established until the last two days of January, and reconfirmed about 10 days later. It was also believed by Col Dills, of the SAC Surgeon's office, that this was the probable source of the ban. As to the length of the ban, it was believed to have been until 19 February, as that was the observed date of the start of tomato harvesting.

While the above concerned the in-zone area, Brig Gen Montel stated that insofar as the out-zone restrictions were concerned, they were lifted on 1 February, but how appropriate instructions were issued is not known. Maj Gen Wilson stated that in contacts with some of the farmers in the out-zone it was indicated "that the situation was not clarified several days or weeks after the February order was published."

* JAG, 16AF, reported that there was one claim for nearly a million dollars from a land developer who had shoreline property upcoast from the scene. A British combine had taken an option to purchase, but after the accident dropped the option. This claim was later withdrawn.

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General Wilson, in considering the marketing situation, said that:

> ... coordinated and well conceived plans to re-establish the market for produce was totally absent. The JEN told USAF personnel that their role was one of advisory insofar as relating pertinent information outside the zone ... Limited observations and hearsay lead me to believe that the Governor, Minister of Agriculture representatives, JEN, etc., were not on the same frequency, consequently an utter state of confusion continued to prevail for several weeks after the 1 February order.
>
> ... the need to start harvesting and re-establish the market was again brought to Gen Montel's attention. After one of his many trips to Madrid, he finally informed me that CAT (Government Supply Agency) had been instructed to come into the area on 16 February and re-establish the market. Apparently buyers arrived about this time but some one had failed to notify local authorities and/or the growers. Consequently produce was not available for the buyers because harvesting had not been re-energized. Finally, on 21 February some harvesting and buying was observed. This however, seemed to be on a hit and miss proposition. Practically all harvesting and buying ceased on or about 25-26 February since it became evident that tomatoes had become too ripe for shipping. Although some fields were harvested for marketable tomatoes and beans after about 21 February, many farmers refused to take any action and obviously were going to depend upon the claims procedure to recoup any losses.

Thus, it can be seen that there was considerable confusion concerning the marketing, and at the same time the psychological situation must be considered. The fields had been barred to the farmers, there was an air of mystery - the subject of radiation was little understood by the local people, and the supposed dangers and results were undoubtedly intensified in their minds. This would spread to the buyers, and without firm, direct information to the contrary, fear would offset commonsense, upsetting the Palomares area economy.

ALLEGED INJURIES:

While there were no direct injuries resulting from this accident, there were claims made for indirect injuries suffered on 17 January. In three cases <u>ex gratia</u> payments were made, which, in effect, denied the claim but did pay some compensation as a matter of "favor."

.* The mother-in-law of a lady of about 75 years, allegedly fell

> ... when she tried to leave the house in the moment of the accident under the impression that parts of the airplanes were falling on her house, she broke both arms in the fall and also some trouble to her leg, and after being attended by the doctor she is now unable to use her arms and she needs a person with her at all times to care for her. And on top of all this trouble she has been left in very bad

* File AFE/66-22136/FS; 52548

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> physical condition and liable to have an embolism which could cause her death. And for this reason I am requesting the amount of 100,000 pesetas as payment for all the consequences caused by the accident or that could arise in the future to the above mentioned person as a result of this accident....

Four months after the accident, on 23 May, died, allegedly of the injuries suffered on 17 January. The daughter and son-in-law presented a claim, for the deceased elderly lady, asking the $1,666.67 on 1 March. This was included along with a property damage claim of 940,640 pesetas ($15,677.33). As this was over the approving authority of the Commission, the claimant indicated a willingness to amend his claim to $15,000 to allow it to be handled locally. The payment made to these people totalled 364,377 pesetas ($6,079.03), of which 36,000 ($600) was ex gratia for the claimed personal injury to the mother. As one emergency payment of $2,400 pesetas had been made to Flores Martinez on 9 February, the last check was for 361,977 pesetas which thus recovered the emergency payment. The total amount was accepted by and his wife, on 20 June, and the acuerdo was signed that day.

On 8 August, the daughter presented another claim in her mother's death for 250,000 pesetas, and the next day her husband claimed additional money (616,219 pesetas) in connection with crops. The Commission did not consider that there was merit in this new claim since payment had been made on recognized factors and no new evidence of loss was presented. On 17 August they were told that since they had signed the acceptance agreement on 20 June as "full and final settlement of all damages," a new claim could not be considered. No further word was heard from this family.

* A claim for medical expenses to treat a case of eczema on the left hand of was made on 18 April. Allegedly this was contracted when assisting in recovery of the bodies from the aircraft wreckage. The claim totalled 13,553.85 pesetas ($226.12), which included 600 for the doctor's fees, 5,403.85 for medicine, 5,550 for 37 days of lost work,** and 2,000 for clothes. The claim was accompanied by a statement from the parish priest that this man had helped in the recovery of the bodies.

Since the medical claim in connection with this was not supported by sufficient evidence that the cause of the eczema was the handling of the accident victims, legitimate payment could not be made on that basis. Also, this was not on the workers list and the claim for lost wages could not be granted. As for the clothes allegedly damaged as the result of the recovery work, there was some hedging on that when asked to bring the suit in. At first he said he had paid 5,000 pesetas for it in France a year past, and that it was at home; however, when told to bring it to the office he changed his story and said that it was burned, and in the garbage, and could not be seen. Based on this evidence, the entire claim was disapproved on 22 April.

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* AFE 66/22610/FS; 52433

** 18 January - 23 February 1966 @ 150 psts/day

was not satisfied with this decision and he wrote a letter to Mr. Duke, the U.S. Ambassador to Spain. He said that he had helped in the rescue work and had then found medical treatment necessary for 27 days, and he felt that the Commission had put aside his claim without justification, particularly since another certificate from the priest substantiated his statements of assistance although not of the medical treatment. He also said in the letter that he had been offered 5,000 pesetas by the Commission which he had refused since his costs had been higher than that,* but that later, on 23 April, they had told him they would give him nothing. His letter ended by saying that he was "capable of directing myself to the President of the United States."

A form letter was used by the Embassy to forward this piece of paper to the Judge Advocate for a reply to be made directly to The case was reconsidered and the Commission decided to award him 3,000 pesetas ($50.00). This was not done on the bases of the medical claim, but rather on the "unselfish acts during the initial recovery operations ... ex gratia." The release forms were enclosed, signed them and returned them to the Commission, and he then received his check for 3,000 pesetas. The case was then considered as closed.

. The third ex gratia case was that of who allegedly injured her back in running from the area where aircraft wreckage was falling. was a widow with six children, and during the summer months of the previous year she had been employed as a charwoman at a restaurant in Palma de Malorca, and had promised to return there in 1966. She filed her claim for injury on 26 April, and four days later submitted a statement from the doctor that she was under treatment. The amount requested was 4,455.25 pesetas ($74.33). The Commission settled upon a payment of 2,500 pesetas, and that was accepted by her on 29 April.

A week later, on 5 May, a letter was received from her stating that she had been unable to return to work because of her injuries, and this loss of pay plus her medical expenses "obligates me to present this claim." She was asked to send further substantiating paper, and she submitted the x-rays that had been made, as well as two prescriptions that she had been unable to have filled due to lack of money. Based on this new evidence the decision was made to award her an additional 15,000 pesetas, bringing the total payment to 17,500 ($295.00). This amount was sent, along with the x-rays, to and on 3 August she signed the acuerdo.

REPRESENTATIVE CLAIM:

A typical claim for damage and destroyed crops was that of , Case Number AFE66/22147/FS, who claimed $13,683.58, and received payments totalling $9,017.74. This total included one emergency payment followed by a claim with two amendments.

* There is no evidence to support such a statement in the file of

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lived with his wife, three sons, and two daughters at Palomares,* where he had farmed for many years. As a land owner he raised tomatoes, beans, cabbages, grain, and alfalfa, and maintained 24 animals (pigs and cows, and two donkeys). In addition to farming his own land he rented land from where he grew alfalfa. He had also entered into share-cropping with two men, with the crop in these cases being grain; one area was shared with while another was shared with Surplus crops and milk were sold on the local market, and the fields of alfalfa were used for animal food. The land concerned was both in and out of the contaminated areas at Site #3.

Estimates of the damages had been included in both the Board of Neighbors and the agronomists reports. Thus, when appeared at the claims office on 11 February, consideration was given for an emergency payment. At that time he required money for payment of a loan that he had obtained from the bank and which he had not been able to pay due to the loss of income from the crops and milk sales. The following day he was paid 50,000 pesetas ($833.33). At the same time he was given the forms to prepare the claim.

His claim was presented on 3 March for 627,363 pesetas ($10,456). Based on the agronomists report, and adding 20 percent of the feed cost claimed (24,000 claimed, 4,800 permitted), part of the milk loss of sale (4,500 claimed, 1000 permitted), and the cost of the dead pig which had been killed by an American vehicle, and the "furniture" lost (farm equipment), an award of 390,260 pesetas was arrived at. From this there had to be deducted the 50,000 pesetas emergency payment. Before this claim could be paid it was found that the investigators for the agronomists had omitted 4,000 square metres of tomatoes that had been destroyed by the crop cutters, with a value of 56,530 pesetas. Then, as discussed in the preceding pages, negotiations were not yet completed. The revised agronomist report of 25 March changed values, and for there was a special annex prepared on 31 March. The first of these changed prices by raising them in general; the second specifically changed claim by adjusting the areas planted in beans and increased the amount by 78,100 pesetas.

With those adjustments, all of them upward, the final award of 1 April was placed at 521,360 pesetas, from which had to be subtracted the 50,000 pesetas emergency payment. was not, however, to receive all of this new total since he was to divide it with the two share-croppers, received 97 percent of the total, or 504,060 pesetas, 10,925, and 6,375. On 2 April, the <u>Acuerdo de Liquidacion</u> papers were signed for those amounts.

The Air Force heard again fro On 20 April he filed an additional claim for 194,000 pesetas ($4,857.29). This claim included tomatoes and grain that was allegedly not included in the first claim, additional pay for feed that was necessary to buy since the fields could not be used for pasture, and a new claim for repair of a threshing area

* Family of wife, sons, , and daughters;

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that was destroyed during decontamination activities. Lost wages for the family was placed at 21,750 pesetas, and for potato and corn crops, which he had been unable to plant, he estimated a 78,000 peseta loss.

A week later this claim was investigated by the U.S. Air Force and it was found that the primary question in regard to the crops was that he questioned the difference between claim and payment. For example, he had claimed 7,996 pesetas in one instance and received only 3,600 in payment. In such cases as this, the agronomists' estimates had been used and the amount paid was all that was allowable. In the case of tomatoes, however, a 10 percent increase (5635 pesetas) was given since the tomatoes had been "in zone" and thus had been completely destroyed and merited this additional sum. Inspections of the threshing area was done by a member of the civil engineering staff, and it was found that it had been badly damaged. An attempt was made to level it, but the Spanish tractor operator only succeeded in making it worse. Since this type of area had to be firm and very even, it was concluded that this was indeed a just complaint, and 6,000 pesetas was given to provide payment for the labor to repair it. Wage losses were denied since this work was within the family and provision for payment of the claim would cover this. The potato crop claim was denied since the ground that had said he was going to plant in this crop had already been claimed in tomatoes, and the tomatoes would not have been completely harvested prior to March; potatoes had to be planted by the end of January to produce a satisfactory crop. The comment of the adjudicator was that "two objects cannot occupy same place at same time," and this claim was denied. As far as the corn was concerned, it was still possible to plant and harvest a satisfactory crop within this season and so that claim was also denied. Also included had been an item of "loss of wages on farm equipment" that he had on "3rd partnership" for a value of 8,250 pesetas. This equipment was found to be the two donkeys that owned. Since these were used only to work on his farm, and were not rented out so that he received no income from their work (other than that from his own use of them), that claim was also denied.

As a result of this investigation an amount of 11,647 pesetas additional was approved, which included the 6,000 for the threshing area, 5,635 for the tomatoes, plus 12 pesetas that the bank would charge for cashing the check. This brought the total payment on this re-opened claim to 532,527 pesetas. This was not satisfactory to and he so stated this fact in a letter on 26 May. In it he reiterated that he had not received adequate compensation for animal feed and loss of milk sales. These items were not increased, nor was the amount of 6,000 pesetas for repair of the threshing area. However, he "emphatically states" that he had canes on hand for future plantings which were destroyed: a total of 300 packages valued at 25 pesetas per package, for a value of 7,500 pesetas. When estimating the damages to the tomato crops, the loss of cane poles had been considered as part of the tomato loss; but, in this case, said that these had not been in use, and since he had reiterated this several times, he was taken at his word and payment included in the claim computation. Thus, the 11,647 peseta increase estimated on 29 April rose by 7,500 pesetas, to bring the entire claim to a total of 540,000 pesetas, for a total dollar payment of $9,017.74. The last acceptance document was signed by on 28 June 1966 for that amount.

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This representative case, while comparatively simple when written out in this form, was only one of the 595 claims presented, but some idea of the work involved can be understood. As may be seen, there was an increasing awareness of what might be claimed, probably developed partly from what other people received, as well as new ideas on what to claim. The claimant was always quite convinced of his honesty and purported rights in these situations. As can be understood, the U.S. Air Force was indeed fortunate to have the support of the Spanish Government in estimating crop damages, and it was primarily on the Spanish that the blame for any inadequate crop payments must fall. For other matters, such as the case of the donkeys and their work in the fields, it became a matter of determining the real facts in the case.

THE CLAIM:

If the total volume of file space is an indication of the historical importance of a claim, that certainly deserves to be included here. played a significant role in the initial recovery of fliers downed in the water and in locating the spot where Weapon #4 entered the water (Section 3). and his vessels were utilized on several occasions by the search forces. He was reimbursed for these activities and for damage to his boat and equipment in the amount of 373,900 pesetas ($4,565.56). In addition, in Madrid on 15 April 1966, Ambassador Duke presented with a medallion and scroll worded as follows:

> "As testimony and admiration of the exceptional talents and profound knowledge of the sea of
>
> which led to the finding of the nuclear bomb which fell into the sea on the coast of Palomares, and as a symbol of gratitude on behalf of my country, I make this document in Madrid, Today, April 15, 1966.
>
> (signed) Duke
> United States Ambassador"

On 24 June 1966 attorney presented a claim on his behalf in the amount of 5 million dollars "tax free" at Torrejon. The basis of the claim was that had rendered "salvage service" to the U.S. Air Force, both in the recovery of the bomb and in the location of the "black box".

The claim, because of the amount involved, was beyond the jurisdiction of the Foreign Claims Commission at Torrejon and was forwarded through Headquarters USAFE to Headquarters USAF in Washington, D.C. for consideration. Conflicting legal opinions by government attorneys are on file as to the worthiness at law of the claim. Most of the legal questions arose concerning ' activities during the search. The legal brief accompanying

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the claim contends that was only compensated for "lost time" in his fishing enterprise and not for his part in the success of the salvage operation. The United States' position was that was thoroughly compensated for his activities and was acting under contract to our government rather than in a voluntary capacity.

Apart from the purely legal aspects of the case, political implications are apparent from the files. By the time a decision was reached in Washington, the first anniversary of the accident was approaching. Thus, attorney at the time, was advised on 18 January 1967, the day after the anniversary, that the claim had been rejected.

In the interval, several statements by in the press (Europa Press, Pueblo, El Alcazar) indicated his dissatisfaction with his treatment by the Americans. The newspaper Arriba actually conducted a subscription campaign toward the purchase of a new fishing boat for . The response, however, indicated that "his cause had not caught the public imagination."

By 3 May 1967, had submitted through his American council, Lord, Day and Lord of New York City, Memoranda of Facts and Law to the U.S. Department of State. Coordination between the Departments of State, Defense and Justice and the Atomic Energy Commission followed.

At this time, Mr. Herbert Brownell, a past Attorney General of the United States, and then a member of Lord, Day and Lord, continued to press for administrative settlement of the claim. Then followed a period during which there was some question on the part of the law firm as to their authority to proceed on behalf. This difficulty was cleared up by March 1968 when the firm, because the 2-year statute of limitations, filed a protective suit in the Southern District of New York. This filing placed the case in the hands of the U.S. Department of Justice. As a last attempt at administrative settlement, a figure of $150,000.00 was proposed by attorney as "a fair and equitable sum."

By this time, general agreement had been reached by the interested departments of our government that the case should go to court rather than be settled administratively (out of court). The reasoning employed in this decision proceeded as follows: If claim was justified, other Spaniards who were of similar aid during the salvage operations would have similar recourse. The procedure at court would provide direct and regulated access to settlement, if desired, for all. Although many Spaniards had been of considerable help in weapon recovery on land, no procedure for salvage on land exists at law. Thus, action in court would apply only to sea salvage and not create untoward reaction among the Spanish farmers. Reaction on our renegotiation of the Defense Agreement (bases, etc.) with the Government of Spain was also considered. Any action on our part which indicated an arbitrary decision on the claim might raise concern with all claimants and place undue pressure on the Government of Spain during the negotiations. Anti-government groups within Spain had already been using the claims situation as a spark to ignite anti-American feeling in Spain (see "Red Duchess" discussion following).

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The case was settled in Admiralty Court in New York in the Fall of 1971. ' was awarded a consent judgment of $10,000.00.

ANALYSIS OF MINING SLAG:

Mr. Kingery, a representative of the Bureau of Mines, U.S. Department of the Interior, was in the area for a study of wells, craters, and mine shafts, during the search for the missing weapon. As there had at one time been considerable mining activity in this district, including smelting and reduction of ore, there were piles of slag and residue of the mining activity. Some of this material was utilized by the Americans in road construction, in preparation of the camp site, and in building of the jetty used for boats. Some comments were made as to the value of the slag, by the owners, with metallic content stressed, particularly of precious metals. To protect the interests of the United States against possible future claims for the material thus used, the claims personnel asked that Mr. Kingery take samples of the slag and have it analyzed to determine content.

He chose samples, and three semi-quantitative spectrographic analyses were performed. The first consisted of samples from widely separated areas which were combined into one for analysis. The second was not considered as representative, but was one that "indicated special silver element content," while the third was from a residue metal pot from a reduction oven. Mr. Kingery reported that:

> Comparison between these three samples show good correlation between silver (Ag), lead (Pb), and iron (Fe); consequently, they may be considered representative of the slag, although scientific sampling was not conducted.
>
> The spectrographic analysis shown is by weight; probably percentage minimum to maximum ranges are shown. The maximum silver content indicated would not exceed 0.15 percent; overall, all averages will be considerably less.

With this record on file, the U.S. Air Force would be fairly well protected against claims, and is one more example of the steps that had to be taken in this accident case.

THE RED DUCHESS:

The Duchess of Medina Sidonia, known as "The Red Duchess" in the Spanish press, could be described as an agitator. Her activities were generally aimed at discrediting the Spanish government. Because of the presence of United States forces in Spanish soil and the support that the United States government provided to the Spanish regime, she was active in anti-American circles. During the recovery effort, she organized demonstrations against U.S. presence using the dangers associated with nuclear weapons and alleged faults with claims payments as a rallying call.

The Duchess took up the claims cause in earnest as the first anniversary of the accident approached. On 17 January 1967, she organized a "bus march" to Madrid to discuss the

claims of "her people" with the Ambassador. The gathering was dispersed by police and the Duchess was jailed until 20 January.

On 23 January, the Duchess and a party of five, including three dissatisfied Palomares claimants were received at the U.S. Embassy, claiming to represent all Palomares region inhabitants. The group indicated that amicable attempts at settlement would end if "just compensation for moral" damages were not forthcoming at once. The group was after an overall compensation for the area. An appointment with the Foreign Claims Commission was offered but declined when the group learned that settlement must be reached with individuals. A meeting between the Claims Commission and lawyers representing 241 claimants did occur on 8 February 1967. The Duchess used the press to advantage by releasing pointedly worded items concerning the meeting (Section 6). The lawyers requested access to commission files to attempt to find some base for additional claims. The commission replied in summary:

(1) Settled claims are closed and commission will not permit them to be opened for review.

(2) Files of open claims in which claimant has not accepted quantity offered will be returned to claimants who request withdrawal. If withdrawal is not desirable, the individual claimants have documents covering amounts claimed and awarded.

(3) Commission would consider claims for new damages or those unknown at time of original filings.

This response led to a threat by the lawyers to the U.S. Embassy that further attempts would be made through Spanish courts. Embassy officials pointed out this recourse was open to them, but expressed the desire that the claimants continue discussions with the FCC. The Duchess read this as a statement of sovereign immunity by the United States. The President of the FCC was replaced as a result of the interchange.

Later in 1967, officials of the Spanish Ministry of Foreign Affairs (MFA) made a statement that implied that Spanish courts had jurisdiction over the U.S. government in regard to the Palomares claims. The U.S. government could not agree to this implication and initiated diplomatic discussions to clear the matter. The MFA indicated that the intention of the statement was that Spanish courts could be employed by Spanish citizens against the Spanish government, not the U.S. government. Settlement within the U.S. government would then be through diplomatic channels. The MFA officials did suggest that the FCC take new initiatives with the lawyers of the claimants, thus keeping the matter out of the Spanish courts. This route was pursued by the FCC with a letter of 22 December 1967. The lawyers responded favorably, recognizing that their clients would fare better following the claims procedure than Spanish courts.

PRIVACY ACT MATERIAL REMOVED

We last see the work of the Duchess in a 2 January 1968 petition to the Spanish Chief of State, Franco, asking for "fair compensation for material losses suffered" and certificates of health for land, animals and people. It is interesting to note that the press for "moral damages" was not included.

SUMMARY:

Essentially, the claims function was charged with the responsibility of seeing that "the claimant shall receive compensation for the actual damage sustained as substantiated by the evidence." Table 5-3 provides a summary of claims situation through January 1973.

In reviewing the entire claims program, the first President of the FCC expressed the opinion that a Foreign Claims Commission is not an appropriate agency for disasters of the magnitude of that at Palomares. He suggests rather than an international agreement, in the sense of 10 USC 2734b, should be employed in the future. Another mode of operation would be through SOFA (Status of Forces Agreement) agreements which allow for foreign nationals to process claims against their own government for damages resulting from U.S. operations. The United States then reimburses that government with a certain percentage (generally 75%) of the settlement. These agreements are common between the United States and NATO nations. An agreement of this type was reached with Spain in 1968.

There is at least one possible claim that, as of this writing, has not been filed. The potential, however, is present. The claim would probably come under the previously mentioned Spanish Law of Nuclear Energy of 1964. The statute of limitations can reach for 20 or more years. was 12 years old and living in Palomares at the time of the accident. At the age of 18 he entered the hospital in Barcelona where he later died of "cancer of the blood." It is not known at this time if the boy was among those tested in the JEN's whole body counting program. It is additionally understood that an attempt may have been made, to run samples of his blood for a plutonium determination. This death may have had considerable impact on the Palomares population. Many minds may question the worth of the official assurances concerning "no danger from radioactivity."

The Palomares claims program was lengthy and caused considerable personal and political friction, both in Spain and in the United States. If there are lessons to be learned, they can probably be summarized as follows:

1. Close and continual coordination between the foreign government, U.S. diplomatic officials, andthe claims operation is required.

2. A strong public information program initiated by the foreign government to explain, in full, the procedures and basis of settlement should be pursued.

TABLE 5-3

CLAIMS SUMMARY

	September 1966	June 1970	October 1970	January 1971	February 1972	January 1973
Total Claims Received	595	644	644	644	644	644
Total Dollars Claimed*	6,533,383.13	7,839,519.63	7,839,519.63	7,839,519.63	7,839,519.63	7,839,519.63
Total Claims Paid	492	529	530	533	535*	536
Total Dollars Paid	555,456.45	696,299.45	697,663.73	699,917.12	710,462.12*	710,913.93*
Total Claims Denied	91	98	98	98	98	98
Total Claims Abandoned	00	7	7	7	12	10
Total Claims Open	12	10	9	6	0**	0
Total Dollars Open**	5,924,957.58	5,099,749.13	5,096,362.41	5,067,372.75	0	0

* Includes claim of 5 million. The claim was denied but is included to indicate the total dollar cost. sued at admiralty and received a settlement of $10,000.00.

** Several claimants accepted partial payments but refused total settlement. Several attempts were made to conclude the negotiation. The cases have lapsed and are considered closed. It is possible that these claimants are anticipating later claim (10-20 years) for radiation associated damage claims.

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PRIVACY ACT MATERIAL REMOVED

SECTION 6

PUBLIC AFFAIRS

FIRST NEWS:

At 170945Z January 1966, the 16AF Director of Information was informed of the mid-air collision and within five minutes the news had been relayed to his SAC counterpart. Before JUSMG and U.S. Information Service (USIS) could be notified the Associated Press correspondent from Madrid called. He had already received information on the crash from a correspondent in Vera, and wanted more details. By 1130Z seven more queries had been received: UPI, Westinghouse Broadcasting Corporation, Europa Press, Reuters, ABC, and Stars and Stripes, and the public relations office of EUCOM, Camp de loges, France. Very little information was available at Torrejon, as a result only the home bases of the aircraft and the fact that they were flying a refueling mission on a routine training flight were given after permission had been obtained from SAC. The names of the known survivors were released as they became available. In conformance with policy of not giving out names of casualties, those names could not be given until the next of kin had been notified.

The news agencies did not wait for official releases and the first dispatch on the teletype receiver at Torrejon was from UPI at the Hague at 1130Z. The Dutch vessel Willem Koerts had radioed that two jet fighters collided in the Cartegena area, with one ditching in the Mediterranean, and the other continuing its flight. The Associated Press (AP) released a dispatch at 1230A, followed by additional ones at 1240A, 1328A, 1407Z, 1506A, and 1805Z, as well as a special bulletin at 1255Z. Considerable detail was given, such as four parachutes seen descending, the name of the survivor on the beach who had been interviewed ( ), a statement by the Spanish police that four charred bodies had been recovered, and it was not stated whether or not the B-52 carried nuclear arms. The 1805Z release listed the names of the four known survivors as supplied to both AP and UPI by the 16AF.

Since had been interviewed by UPI, SAC stated that valid questions could be answered so as not to embarrass the United States and the Government of Spain. That evening SAC established that no press interviews would be permitted at Torrejon even though reporters were aware that three of the four crew members had been returned to the hospital there.

Meanwhile SAC was busy preparing a release. The draft was read over the telephone to the 16AF at 1530Z; however, until clearance with USIS, JUSMG, and the Embassy and the Spanish Government could be obtained, it could not be made public. At 2030Z, eleven hours after the accident, the official release was received by 16AF, relayed from USIS at Madrid, as a joint DOD-State story approved by the Spanish. Within 15 minutes it had been sent to AP and UPI. Being brief, only the basic facts were stated:

Rec'd Fr Mr. Bell, USIS, 2130/17 Jan 66 -

<u>For immediate release by 16 AF</u>

Joint DOD-State Msg - GOS approval

> A B-52 bomber from the 68th BW at Seymour Johnson AFB, N.C., and a KC-135 Tanker from the 910th ARS at Bergstron AFB, Tex. crashed today southwest of Cartegena, Spain during scheduled air operations. There are reports of some survivors from the crews of the acft. An AF Accident Investigation team has been dispatched to the scene. Additional details will be available as the investigation progresses.

Released - 2145

Although information concerning nuclear weapons could not be released it is noteworthy that the Associated Press had asked about them on 17 January. At that time the only answer was a truthful one, information concerning the weapons was not available. It was no longer possible to adhere to the usual policy of not discussing nuclear weapons, and by the afternoon of 19 January, radiation hazards and lost bombs were definitely the subject of the day. The Reuters representative in Madrid called concerning a reported "450 airmen with Geiger counters looking for nuclear material." The American Broadcasting Company reported, also from Madrid, that "several hundred U.S. airmen combed the Spanish countryside today looking for - to quote - ' the nuclear weapon or weapons that were aboard the crashed B-52.'" At 2105Z SAC advised 16AF that two UPI dispatches, both datelined 20 January, had been received. The lead paragraph of the first read:

> Residents of this tiny village (Palomares) waited nervously while the U.S. Air Force searched for an atomic bomb carried by a nuclear bomber which crashed after colliding in the air with a KC-135 jet tanker.

The second article, written in a personal vein, started:

> Searching for a missing atom bomb is not exactly my idea of the best way to spend a holiday on the sunny coast of southern Spain.

The first story included the "no comment" statement of personnel at the site and at Torrejon, following with the fact that hundreds of airmen were hunting for a nuclear device. The reporter went on to say that the immediate crash site had been evacuated, but the general area was not, and that about 50 Guardia Civil were preventing civilian entrance to the crash zone while the Americans hunted for some object.* Then, as if to answer the question of how

* He also reported two interviews to reflect local reaction, one against, the other for the situation that existed. The first, after describing how he had walked up and touched the bomb, said that he considered "it intolerable that the Spanish Government allows these planes to fly over Spanish territory." The other considered that it was much more dangerous to give Russia "the edge in the cold war."

he surmised that it was a bomb missing, and not some other type of equipment less deadly, the personal article explained his sources of information:

> I saw American airmen, some of them carrying Geiger counters and many of them wearing radiation detection badges, scouring the area in the search for the missing bomb.
>
> I was stopped by a guard in the area. He asked me if I could speak Spanish and I told him I did. Then he asked me if I could go with him to a nearby bean field where a Spanish farmer was cutting his crop.
>
> The guard explained that the Guardia Civil had been instructed to clear the area of all people because it was contaminated.
>
> After further questioning, the guard said one nuclear device was missing from the crashed B-52 ....
>
> The guard said that two bombs were found during this first day's search in the arid, sparsely-vegetated hills ... and said that the last bomb was found there, right on the beach.

With the extensive coverage of the UPI throughout the world the implications of that release could not be ignored. At 1230Z, 20 January, the second official release was received at Madrid and distributed. In this it was admitted that the bomber had been carrying nuclear weapons, but the fact that a bomb had not yet been found was omitted:

> The Strategic Air Command bomber which was engaged in a refueling operation off the coast of Spain, and suffered an accident with a KC-135 tanker was carrying unarmed nuclear armament. Radiological surveys have established that there is no danger to public health or safety as a result of this accident.

While these news releases, press stories, and directives were being issued, the Embassy, at the direction of DOD and State, was preparing a statement for release. It was coordinated with JUSMG and then went to the Spanish Foreign Office. It stated, in brief, that Ambassador Duke expressed appreciation for the assistance given by the Spanish in the rescue work. It also announced that there had been a small explosion of conventional materials, and that radiation monitoring teams were working in the area to "confirm the safety of the spot."

The Spanish, according to a USIS representative, "obviously do not desire that such a statement be released although they appreciate the ambassador's desire to express his thanks." The Spanish also said that they desired to reconsider the release after it was approved by Washington, which effectively would delay its publication. However, the next afternoon, Thursday, 20 January, the Air Ministry issued a release which was carried in ABC, Arriba, and Informaciones the next morning, It really said little, but did explain something of the reasons for the security precautions being taken in the accident area since it mentioned the "secret" nature of the aircraft:

> With reference to the air accident that occurred off the Spanish coast in the province of Almeria, it has been determined that it was a collision between a tanker aircraft and a long range American jet plane while a refueling operation was underway.
>
> The authorities and civilian personnel of that area went to help the crews and they managed to save four flyers and they helped put out the fires of what remained of the aircraft that collided and which had fallen in the neighborhood of the village of Vera and Palomares.
>
> The last area, five kilometers in diameter, over which the debris was scattered and the recovery of elements of a secret military nature have made necessary the search and safety measures taken by this ministry in order to obtain full information and analyze the conclusions of flight safety procedures.
>
> The Air Ministry appreciates the cooperation given by the local authorities and civilian personnel and their spontaneous and courageous help which made possible the assistance given and the work that is underway to complete the investigation with added safety.

Friday, 21 January, was quiet, with no new releases, but with a bit of advice from SAC: there was no special guidance for handling of newsmen, and no objection to photographing unclassified wreckage, but personal safety was paramount. The only comment to be made was "investigation continuing." While silence was being maintained by the military, the following day the Associated Press told of an interview in which "an official Spanish Government source" told that they had medical specialists in the area, but stressed that even though the reports on contamination were not yet complete, there was very slight radioactivity. However, there was no danger even to those working directly in the area, and the amount of radiation present was much the same as encountered in many laboratories.

In response to a request by U.S. Air Force a rationale of the release policy was sent from Palomares the next week. It was felt that a new policy was needed since it was quite apparent that something more than a normal accident recovery operation was going on:

> Newsmen in the area see large numbers of men, many carrying radiation detectors, searching the countryside. Also, decontamination personnel wearing distinctive clothing, using surgical masks and gloves are seen throughout the area ... We believe we should be allowed to confirm that there were unarmed nuclear devices on board, and use a statement to the effect that the search is for the purpose of absolutely insuring that there is no danger to the health of the population.

As there were U.S. Navy ships in the area there were further requests for information. The Navy proposed a release with which they would answer those queries. In it they said that they had at the site a special search and recovery task force with 10 to 12 ships as well as underwater search equipment which was being brought in. This proposed release was sent

to USCINCEUR despite the fact that on the previous day the Commander, Sixth Fleet, had passed along specific guidance from "higher authority" that no news releases were to be initiated. Additionally, the 16AF was to receive all news queries, and Navy relations with the press were not to include taking aboard of any newsmen or accepting press traffic for them.

USCINCEUR approved the release, and Torrejon told Maj Gen Wilson of this on the morning of 25 January, but said that since DOD had not yet concurred it could not be released. JUSMG did not approve the story and also pointed out that JUSMG had named the 16AF Information Directorate as the one point of contact, and they would coordinate with the Embassy, and stressed that the Spanish had asked that all releases be coordinated with them "to allow their official releases to be in consonance with U.S. releases."

In an apparent attempt to satisfy reporters, a third official release was made:

> Elements of the U.S. Navy and the U.S. Army are assisting Spanish authorities and the U.S. Air Force in the search for wreckage of the B-52 and KC-135 aircraft which suffered an accident during a refueling operation January 17.
>
> Air Force officials reconfirmed that radiological surveys have found no indication of danger to public health or safety as a result of the accident.

A restatement of the "no comment policy came from DOD on 25 January, which named also the releasing agency in Spain:

> ... there should be no news releases or public statements of any kind on this subject without prior approval from ASD(PA). Before granting approval, ASD(PA) is coordinating with other military and defense agencies, State Department and U.S. Ambassador in Spain. In virtually all cases, releases will emanate from Embassy, Madrid after proper coordination with Government of Spain (GOS).

As explicit as these policies seemed to be for the personnel who sat in Spain, apparently those on the home front were not briefed. There were two articles within a few days that violated these lines. The first appeared in the Spanish ABC, datelined 29 January, in which DOD confirmed that two submarines were being sent to assist in the bomb search. That story was from an exclusive of the New York Times correspondent in the Pentagon. A UPI story on 1 February attributed "informed sources" for their item on submarines making contact with " a missing nuclear bomb lying in 1,200 feet of water off the southeast coast of Spain." Both DOD and JUSMG said that such unilateral releases could only embarrass the United States, and that on-the-scene press relationships became a little strained when reporters in the States scooped their own people at Palomares.

The Armed Forces Communications Service (AFCS) unit at the scene - the 2nd Mobile Communications Group - sent a proposed release to 16AF for approval. Their story told what equipment was at the scene, and included a list of the members of the detachment. Even though it was written as primarily of interest to local Service papers, the Group was told

that the Embassy had been designated as the single point release agency and that the particular story could not be given to newsmen. Then, when more pressure was exerted by newsmen for information on the Navy, DOD continued their policy and denied all requests, and again said that no tours could be given since the Navy's work was concerned primarily with search for wreckage and classified materials. It was not a matter of being selective on who would have publicity, it was merely a matter of saying nothing about anything.

On 3 February, the very first briefing for media personnel was held in Madrid; however, from records of the recovery story, it was apparent that the 16AF public relations personnel were not there to hear the comments. Ambassador Duke told newsmen that 67 objects had been recovered from the sea, none of which had definitely been identified as the missing nuclear device, and that the purpose of the recovery operation, to leave Spain as it was before, would continue until the job was done. He announced the arrival of Jon Lindbergh, of Ocean Systems, who would work with the deep sea recovery portion of the project; that Alvin would start work about 8 February, and that the Aluminaut would arrive about 17 February. He also told reporters that it was hoped that unclassified photographs of the operations could be released and that authority for that action had been requested.

EVALUATION OF POLICIES:

It was then two and a half weeks after the accident, and there came a lull in both releases and directives. Three official statements had been given out: (1) the occurrence of the accident; (2) the bomber was carrying unarmed nuclear weapons, and (3) elements of the Navy and Army were assisting, and there was no danger from radiation. JUSMG's original directive naming the 16AF to handle releases had been changed by the DOD directive naming the Embassy as releasing agent.

DOD took this time to request a report on current and future public affairs activities as seen from the angle of the people in Spain. As mentioned before, one brief report had been filed from Torrejon, at DOD's request, but now more comprehensive information was desired, such as reactions of the press to the "no comment" policy, the degree of relationship with the Spanish, and problem areas.

In reviewing the situation, 16AF replied that interest of the press in the accident was shown by the fact that at Palomares there had been 54 newsmen, representing 7 countries, who had made 101 visits to the press center in this period. Also there were others in the area who had not officially contacted the press center. At Torrejon, representatives of 23 media of 6 countries had made queries. The reaction to the news ban was generally hostile, with "indignation, turning later to frustration." Due to pressures on reporters, the lack of factual information resulted in their turning to local Spanish and/or Americans at the scene, and that only led to "speculation and outright fabrication." Generally there had been little difficulty with the Spanish press since their reporting was usually factual. Rather, they had decried the sensationalism of some items that had appeared in the French and Italian papers, as they were to do a week later with an English release. For the future, the problems outlined reflected the experience of the past 17 days:

We believe there will be increasing pressure for information on naval activities, particularly on the undersea research vehicle operation. It is anticipated that the press will strive to keep the story alive and in the absence of official comment, may begin to speculate on such areas as water contamination, etc. Decontamination of crops continues to be an area of concern; however the GOS coordinator is making every effort to dispel any false fears on this. We believe that Navy furnished photography on their operations could reduce considerable pressure on the advanced camp and dispel many rumors.

In the area of relationship with the Embassy it was felt that the climate was satisfactory. Ambassador Duke had visited Palomares on 3 February and while he made no direct comment on media handling, he appeared to consider the situation favorable. Relationships with the Spanish were satisfactory, and information was exchanged so far as security permitted. For discussion of the Spanish reactions to the accident, DOD was referred to a report prepared by the AFSSO (Air Force Special Security Office). In that it was stated that the "population has not been overly affected by the incident." The first reactions were those of concern over the crash and the deaths. This was replaced by curiosity as recovery teams moved in, and with newsmen flocking to the scene a certain air of the importance of Palomares began to appear. However, when radiation checks were started and fields were closed off there was some alarm, but some of this was dissipated when the United States paid for the crops it destroyed, and when it was seen that some of the foodstuffs were being eaten by the Americans.

This summary of relations was sent to DOD on 5 February; however, two days prior the Public Affairs Division, Assistant Secretary of Defense, directed evaluation of the situation in Spain. As a result, Col. Donald C. Foster was sent from Washington to Torrejon and then to Palomares. He discussed the situation with JUSMG, Embassy, 16AF and Navy personnel, and reviewed the newspaper stories. The consensus of opinion, diplomatic and military, was that:

> ... immediate positive action is required to reverse the damaging news stories which have been, and are continuing to be, published worldwide ...
>
> That a joint press briefing be held no later than 16 February at either Torrejon Air Base or preferably, if communications difficulties can be overcome, Palomares. On that occasion we should release a Defense Atomic Support Agency prepared paper on radiation hazards and should confirm the fact that we are searching for a nuclear weapon ...
>
> That Commanders, 16AF and TF-65 be authorized to release, on a continuing basis, unclassified photography of their operation.
>
> That Commanders, 16AF and TF-65 be authorized to provide, routinely, briefings and land and sea press "tours" of their decontamination and search areas, the sea tour to be confined to light LCVP or similar vessels.

That U.S. Embassy, Madrid, 16AF and TF-65 establish an on-site ad hoc public affairs working group to make appropriate recommendations as dictated by subsequent events.

That Commander, 16AF control all on-site press activities. Col. Foster pointed out that there were other factors contributing to adverse and speculative press stories. Living conditions were not of the best, transportation was difficult to obtain, and reporters were usually not equipped to work under Spanish winter-time conditions. These personal inconveniences, while not exactly the concern of military authorities, "militate against favorable press coverage," particularly when the "vacuum of official news" was added. With regard to the official Spanish attitude on news releases, he stated that it was his "conjecture that present Government of Spain (GOS) news blackout is based on its awareness of U.S. news policy." He also met with the ambassador just prior to returning to Washington and found that Ambassador Duke was in accord with trying for a more liberal public affairs policy and had so informed the State Department. Unofficially, it was also felt that the Spanish would go along with such a change.

Ambassador Duke agreed to the idea of a press conference which would be held on Wednesday, 16 February, at Palomares, with the local Spanish governor of the region, General Montel (or his representative), General Wilson, and Admiral Guest attending. Topics of discussion, which would be furnished by DOD/AEC authorities, would include a detailed statement concerning radiation hazard. Colonel Foster had included in his report a suggested introductory briefing that outlined the two problems being encountered. One was the search which would mention that one of the nuclear devices had not yet been uncovered, and the second was the return of the area to its original condition. The two speakers, one to cover land search, the other sea activities would be introduced at this time. The conference never materialized.

JUSMG also had some ideas on the existing policies and sent them along to their next higher headquarters, USCINCEUR. They agreed that the coverage in Spain had been factual, but that the paucity of information at the beginning had created an unwholesome situation. Their recommendations, in brief, were that:

The first release should be made as soon as possible after the accident and should include a direct admission that nuclear weapons were involved, but that no danger to public health existed.

A more liberal attitude toward news releases should be maintained to prevent a feeling of censorship.

PRESS POLICY REVISIONS:

It was hoped by those at Palomares and Torrejon that all of these recommendations might bear quick results and a loosening of the strings on releases would occur. The first step in that direction occurred on 12 February when a coordinated DOD and Department of State

release admitted that a nuclear weapon had been lost, and that contamination had occurred but that there was no sign of health hazards. It was sent to the Spanish for coordination; however, no reply had been received by the end of the month although it had been reported by USIS about 24 February that General Munoz disagreed with two items and would not clear it; what those were was not stated. So it appeared that another obstacle had been placed in the way of a more open policy.

Initiation of a revised press policy occurred when Jose Maria Navascues, President of the Junta de Energia Nuclear (JEN), discussed the radiation situation and recovery operations with newsmen. A lengthy article was published in Informciones and Pueblo on 1 March. The reporter stated that the accident "had produced no little speculation and resulted in confused information," and that to clarify the situation he had visited Navascues who had openly answered some questions. He said that there had not been one case of radioactive contamination found in Palomares, and that 17 scientists and technicians were working in the area on the radiation problem. He discussed the shipping of 6,000 tons of contaminated soil to the United States. While this was being published, including use of a complete paragraph of the previously proposed release, and paraphrasing of other information, the decision was made to proceed with the drafted statement as the fourth release in Spain. This was accomplished at 1245EST, 2 March. The statement made by Navascues may be seen in its entirety on the following page, with the fifth paragraph concerning radiological surveys. The same day the AEC in Washington issued a release on the radioactive soil:

> Following the January 17 collision of a B-52 carrying unarmed nuclear weapons with a KC-135 refueling plane, approximately 1500 cubic yards of earth and vegetation were collected in southeastern Spain to preclude any possibility, however remote, of public health of safety hazard. There was no nuclear detonation.
>
> The earth and vegetation contained only small quantities of radioactive material scattered when the nuclear weapons impacted. The material will be shipped to the AEC, Savannah River Plant, near Aiken, South Carolina, where it will be buried in the same manner as other low-level radioactive waste material is routinely disposed of.
>
> The material is being packed in 55-gallon drums. The levels of radioactivity are being carefully monitored to be sure they are well within the standard limits of such shipments.

Since it was public knowledge that the bomb had been lost, DOD provided more information through a question-and-answer form distributed on 2 March in Washington. Items of interest included how many bombs were involved, the characteristics of the plutonium and the alpha rays it emitted, as well as safety measures built into the bomb. Concurrently, the State Department was including information in their daily briefing which used the DOD release, including a question and answer period. Some of the same questions were answered in the DOD release, answers to the unexpected questions were wired by DOD to Spain, while the State Department's USIS issued a talking paper.

APPROVED DOD NEWS RELEASE, 2 MARCH 1966

Search is being pressed off the Spanish Coast for the recovery of material carrried by the two planes involved in the recent air collision and for fragments of wreckage which might furnish clues to the cause of the accident. Included aboard the B-52 which collided with the KC-135 tanker were several unarmed nuclear weapons, one of which has not yet been recovered.

When this search and investigation have been concluded further announcement will be made of the results.

The impact of the weapons on land resulted in a scattering of some plutonium (Pu 239 and uranium (U235) in the immediate vicinity of the point of impact. There was no nuclear explosion.

Built-in safeguards perfected through years of extensive safety testing, have allowed the United States to handle, store and transport nuclear weapons for more than two decades without a nuclear detonation. Thorough safety rules and practices also have been developed for dealing with any weapon accident which might result in the spilling of nuclear materials.

Radiological surveys of the Palomares area and its human and animal population have included detailed laboratory studies by leading Spanish and U.S. scientists throughout the 44 days since the accident. They have obtained no evidence of a health hazard. These experts say there is no hazard from eating vegetables marketed from this area, from eating the meat or fish or drinking the milk of animals.

Steps have been taken to insure that the affected areas are thoroughly cleaned up, and some soil and vegetation are being removed.

These measures are part of a comprehensive program to eliminate the chance of hazard, to set at rest unfounded fears, and thus to restore normal life and livelihood to the people of Palomares.

Release Time, 1735Z (1245EST)

DOD issued a new policy on publicity. Coordination was to be accomplished with the Embassy, but 16AF and CTF-65 were to handle questions concerning search and decontamination operations as routine public affair items. Dr. Langham, or his Spanish counterparts in the nuclear energy field, were to answer questions on technical matters but no statements were to be made on the quantities of materials being removed or its disposition. In Madrid the ambassador directed that an "information policy coordinating committee" was to be established, chaired by USIS, as the Embassy's Counselor for Public Affairs, and that JUSMG, 16AF, and possibly CTF-65 should be represented. He stated that:

In the future I would like any new press statements, after coordination, to emanate from an Embassy spokesman. Such statements, as well as those statements contained in the State/DOD message, can be routinely given newsmen by military information officers, both on the scene and at Torrejon Air Base.

Consideration of the AEC statement of 2 March could also be handled in the same manner, but that technical questions should be referred to the Embassy. In organizing such a committee Col. Foster's recommendations were closely adhered to with the exception of meeting in Madrid rather than the site of operations.

Ambassador Duke and Information Minister Fraga swam in the 59° water of the Mediterranean to prove that no danger existed from radiation. Sixty-three newsmen assembled on 8 March. A fiesta atmosphere prevailed, and several banners were displayed reading "Viva la Wilson," "Viva la Americano" and "Las Tropas de Wilson's Han Sido Correctas con Palomares." The following day, 28 reporters were taken on an LCU to tour the Navy area. They were permitted to photograph the pocket submarines, and were given a briefing by Admiral Guest on the sea search. Upon returning to shore they were given a detailed and comprehensive briefing by Gen Wilson followed by a visit to Site #3. Admiral Guest discussed the search area, depths of water, types of equipment and their capabilities. Reaction to this unfamiliar treatment was favorable.

RECOVERY ACTIVITIES:

On 15 March, at 1100Z, Alvin spotted what was considered to be the missing bomb. Efforts were made to keep the matter somewhat quiet until positive identification could be made. Ambassador Duke instructed that the matter be handled with the "utmost secrecy," and that any announcements would be made by a publicity committee of Spanish and Embassy representatives. However, such secrecy was not possible. Two days later the UPI filed a story from Frankfurt, Germany stating that "officials were virtually certain that the missing bomb had been located in the water, and that a parachute for the weapon had been recovered." The story seemed to have been written at the scene, but that was not the case. There had been a leak, someone had talked out of turn, or there was some very accurate guesses on the part of an observant reporter. Thus, the Embassy decided to hold a press conference and announce the big event, and the State Department was notified. The press corps members were told to be at the Embassy at 0100 hours 18 March but, 15 minutes before the time, word was received from the State Department that the meeting should be cancelled and no statement given out. Instead of the planned briefing a telegram from Secretary of State Dean Rusk was read to the reporters:

> There have been hopeful developments but I cannot give you further information at this time. If we have a positive identification and recovery, we will so inform you.

It took another day for an approved release to be received in Spain, and on the morning of 19 March, DOD/State Department directed that the "appropriate military spokesman" could make this statement:

> With regard to the unidentified object and a parachute at a depth of some 2500 feet about 4 miles off the shore from Palomares, Rear Admiral William S. Guest, and Task Force Commander, has advised that because of the extremely steep slope of the sea bottom on which the object and parachute are resting, he proposed to attempt first to move them to a more favorable recovery area.
>
> If successful, this course of action will lessen the risk of having the object fall from its present precarious position into much deeper water. When the object is positively identified, an appropriate announcement will be made.

JUSMG did not agree with sole military release, feeling that Embassy and military sources should be authorized joint release. Also, they felt that nothing more should be said until something actually was accomplished. The State Department and DOD agreed that periodic releases would be acceptable, but that full coordination between the Embassy and on-site commanders must be maintained. Both General Wilson and Admiral Guest agreed with this by recommending that the "next release be made when successful identification and recovery were fully completed. Release of the story on the object in the sea was made at 1200Z, 19 March, both at Palomares and at Madrid.

The sixth release did not concern the bomb itself, but was issued jointly on 24 March by Generals Wilson and Montel at the accident site to announce that the last barrels of contaminated soil had been removed from the beach:

> The loading of these last barrels marks the completion of the soil removal portion of our search and recovery operation. Approximately 4900 barrels or around 110 tons of soil have been transported to the USNS Boyce for shipment to the United States. The Boyce will sail for the U.S. later today. I think we have achieved our goal of leaving the Palomares area in the same condition it was in prior to the accident. We will now gradually commence phasing down our camp. However, considerable support will be required for continuing operations by the Navy.

Now that the field of releases to the public seemed to be open, another, the seventh made in Spain, was issued on 25 March, but this time it was made only at Madrid, by the Embassy:

> Admiral William S. Guest, Commander of Task Force 65, advises that operations for recovery of the object with attached parachute (previously located off the coast from Palomares, Spain), are proceeding satisfactorily. These operations must necessarily be accomplished slowly and cautiously due to the precarious position of the object on a steep submarine slope, and the great depth involved. At first weather conditions with high winds and choppy seas continued to periodically hamper current efforts. The limited endurance of the submersibles being employed and the necessity to recharge their batteries after each dive are primary factors which, with weather, control the tempo of our activities. Everything possible is being done to expedite recovery and identification of the object under these circumstances.

This release from Madrid caused considerable unhappiness in Palomares since it had been agreed that all such items would be put out simultaneously in Madrid and Palomares. General Wilson pointed out to General Donovan that fortunately, the release had been a minor one, otherwise the press at the scene would have been "highly indignant." He said for a reporter at the scene to utilize such a release it was necessary to drive about one-half hour to a phone and then struggle with the long-distance communications system of Spain. He considered that the situation was "rough enough without antagonizing them further with advance releases in Madrid."

As noted earlier, there had been one serious leak to the press, and unfortunately there were more with the stability of the Wilson-Montel relations at the site becoming somewhat strained. It was considered that the curiosity of the reporters was only heightened by the policy of "no comment," as evidenced by the amount of coverage in the press of this accident/recovery operation. All during this time enterprising reporters had queried Spanish citizens and American airmen whenever possible, and frequently used them as their "informed sources," but the news leaks that began occurring became embarrassing particularly since they were fairly accurate. General Wilson told SAC and U.S. Air Force of the strained relationships and wrote that General Montel had:

> ... been embarrassed on several occasions when queried by Air Minister La Calle and Captain General Munoz-Grandes concerning articles appearing in the press. These officials are apparently learning more from press releases than from Montel and Donovan. Montel's recourse is to query me. I'm in a quandary as to information that should be passed to my GOS counterpart within security limitations and outguessing what might appear in the press within hours after dispatch of SITREPS (Situation Reports, Navy). Recent Stars and Stripes have carried articles containing practically all pertinent information concerning salvops (salvage operations) of the unidentified object .... In my opinion this situation could jeopardize the future military position in Spain.

The reference to Stars and Stripes, the unofficial military publication in Europe, was to statements made by General Wilson on 25 March to SAC and DOD concerning a story that had appeared in both Stripes and the New York Herald Tribune, Paris edition, that had given as much information as was known at 16AF. Not only did it distress him with regard to his relations with General Montel, it also gave an unwarranted sense of imminent recovery, which was completely false. In reply to this allegation, USCINCEUR said that Stripes had used commercial wire services, either AP or UPI. As the executive agent for Stars and Stripes they had directed the editor, early in the recovery operations " ... to select the wire and service reporting each new development with the most authoritative source and to identify the source early in the story. The Embassy also told the State Department of this problem, and said that they were sending an information officer to Palomares as a representative for the Ambassador and as coordinator for public affairs. At the scene, CTF-65 notified all of his task force personnel that they were to guard against open discussion over voice radio circuits where monitoring or listening might be taking place.

RECOVERY RELEASE PLANS:

Now that the bomb had been identified, and before it was lost again, and then found for the second time, several plans were devised on how to release the news. There were several factors to consider. Recovery might be a simple operation, with the bomb coming up gracefully from the sea bottom, intact, ready to be returned to its homeland. On the other hand there was the possibility that it was not intact, that pressures had damaged it, that low-order detonation had occurred, or something might happen that could endanger the whole recovery action. Also, this was a highly classified item - very few people had actually seen a nuclear bomb. But since recovery was not to be a simple operation there was adequate time to write and rewrite contingency plans and statements.

The first meeting of the "Public Information and Coordinating Committee" was held on 17 March, the day before the midnight press conference was held. Discussion was on release policy and drafting a statement prior to actual recovery. When the Embassy was notified that the bomb had been recovered, the Spanish would be informed and an announcement would be made to the American press. They would also be invited to a press conference in which technical details of the recovery activities would be given.

DOD and the State Department approved a release outlining facts of the rescue; that the bomb was intact, there was no radioactivity, and that the contaminated soil was on its way to the United States, and Camp Wilson was being phased down. Then, in another message they added some information concerning activities at the time the bomb would be raised. They felt that General Wilson and AEC representatives should be there when it was raised from the water. If it were intact, General Montel, or another Spanish official, would be invited to view it as well as, possibly, a member of the JEN. The press would be permitted to photograph it which would be a milestone in the history of nuclear bombs. General Wilson did not believe this action would be in the best interest of the recovery project since it would be necessary first, to monitor for radiation, and second, to perform necessary safety measures. Then, the Spanish could be invited to the viewing, and photographs suitable for the press could be taken.

The Embassy became involved in the planning and when Ambassador Duke's representative, William Bell, arrived at the scene the afternoon of 26 March, he brought an elaborate plan. The raising of the weapon was to be witnessed by General Munoz-Grandes and other Spanish officials who would accompany the ambassador to the scene. USIS had alerted the press that they should stay close to Madrid and apparently gave them the impression that photography of the recovery would be permitted. This was done without coordination with the on-site commander. In this apparent attempt to placate the press for past actions, safety factors were ignored along with the possibility that something might go wrong in the recovery activity.

This plan was discussed with General Wilson as to its weaknesses. Primarily there was no way of accurately predicting when the bomb would be lifted, also a dignitary such as Munoz-Grandes was not a person that could be kept waiting. The reason for the exhibition of the

recovery was to establish credibility, hence the on-scene commanders both felt that photographs of Spanish Government officials viewing the bomb was necessary, and would be sufficient, although for countering propaganda from Communist elements, press coverage might be desirable. They felt that "beyond doubt credibility" must be established particularly since the Soviets had expressed an interest in international verification of the recovered weapon, as had U.N. Secretary General U Thant. Participation by outside agencies was not desired. However, Ambassador Duke did ask that consideration be given to press viewing and photography, perhaps by a "pool", which would then furnish coverage to all newsmen.

For a time it appeared as though no plan, regardless of acceptability, would be put into effect. The Navy sent a proposed release for coordination in the afternoon of 26 March;

> .... in a first attempt to recover the object with a parachute attached in the waters off Palomares, Spain, the lift line parted as a result of having been caught in, and cut by, the fluke of an anchor which was part of the recovery rig. The object and parachute are still in the same area but have moved from the position at which they were originally located, making the next recovery attempt even more difficult and lengthy.

Prior to this release the Sunday morning papers (ABC, Arriba, Ya), headlined this attempt at recovery. This rather outdated the Navy story but it was released anyway, after coordination with the Ministry of Information, as the eighth release in Spain. When the Navy was informed of this release, they were also informed that Mr. Bell could coordinate - in the name of the Embassy. The text could be released to Madrid at the same time it was given to General Montel. In Madrid, the Embassy and Torrejon would handle the release. General Wilson did not agree with all of this proposed policy change, and stated that rather than Mr. Bell giving the releases to Montel, he would do it himself, which was logical in view of the close Wilson-Montel cooperation that had been achieved. Also, it was believed that it was not necessary for the GOS to clear releases. They should be furnished the text and the release time prior to actual release.

The fact that the bomb was lost again as the result of this recovery attempt, and not found until 2 April for the second time, did not stop the planning process. General Wilson told SAC's General Ryan of the unrealistic, theatre-like plan of the Embassy, and said that the press representatives were definitely restless as they had been alerted for imminent recovery of the weapon and nothing was happening. He said that the alternative of the Embassy plan was the small photo pool, with one American, Spanish, and international photographer doing the coverage. Mr. Bell then conceived an idea known as Plan Able. In this plan the press were to be alerted when recovery was imminent and told to be at Camp Wilson within a maximum of 10 hours.* They would then be taken by landing craft to the recovery ship (USS Albany) which would be placed into a position so that photographs could be taken.**

* Approximate driving time to the scene from Madrid.

** Gen. Montel and JEN representative were to be present with the weapon.

After the press returned to shore, either CTF-65 or Mr. Bell would issue the final announcement in both English and Spanish. Within 24-hours another trip would be made to the flagship for a chronological briefing by Admiral Guest on the entire recovery operation. General Wilson did not approve of this plan either and felt that Admiral Guest would agree with him. He realized that things could move much too swiftly to permit arrival of the newsmen and any other personnel considered vital to the Embassy plan. Mr. Bell said he stood their reasoning, but recommended adoption of the plan or a modification acceptable to the State Department and DOD, but General Wilson was still very much concerned with safety and security, having just gone through an arduous and tedious decontamination process.

The State Department and DOD agreed with General Wilson, but added that "the credibility of the whole operation and the closing off of further speculation by the press" was also required. They had given latitude to the Embassy and the on-site commanders in evolving and executing a plan to cope with the situation, such as the use of the photography pool, with the final briefing by Admiral Guest to be done as soon as possible to prevent further delays. However, if coverage by all media could be accomplished rather than the "pool" coverage, that would be preferable. From this the Embassy representative arrived at Plan Baker. It was different than Plan Able in that a pool would be utilized with members agreeing in advance to make the material available "uniformly and simultaneously to all other news organizations without payment of any kind." All pool members would be pictorial media, with one still, one TV, and one newsreel cameraman. The exposed film would be taken by aircraft to Torrejon, and there released. Non-pictorial reporters could not participate in this portion of the operation but would be free to report on the recovery at the same time the contingency statement was released at Palomares and Madrid.

Thus, Plan Able would let all the concerned media view the remains, while Plan Baker would permit only the designated three to photograph the object. The latter plan was considered as being unsuitable because of the possibility of antagonism so it was discarded. Therefore, the execution of Plan Able must be well coordinated in order to assure success. After the meeting in Madrid, General Wilson and Admiral Guest met in Palomares to agree upon a suitable plan to fulfill the needs of the press, and at the same time to provide credibility to satisfy the requirements for the DOD and State Department.

As a result of the Palomares meeting, it was decided that press members would be taken from the shore to the USS Albany, and from that vantage point the recovery ship would come alongside. This would permit photographing of the weapon and at the same time it could be inspected by General Montel and a JEN representative. While safing actions would be completed and identification marks covered prior to exhibiting the bomb, any disassembly for shipping would not be done until after the Spanish officials and press corps personnel had seen it. The Embassy concurred with this, asking only that sufficient time be given to permit the ambassador to arrive at the scene to be with the newsmen.

CONTINGENCY STATEMENTS:

The first contingency release relating that the lost bomb had been found and that the salvage operation was essentially complete, was prepared on 3 February in order that it could be released at the proper time. The draft was prepared under the assumption that the weapon would be recovered before decontamination accident investigation could be completed ashore.

Since that statement was not acceptable to the situation that later existed, i.e., the wreckage had been cleaned up, the contamination controlled, and the accident investigation completed, a new release was prepared in late March, after the weapon had been found, but before it was recovered. The Embassy sent the following to Washington for coordination:

> The fourth and final weapon from the January 17 crash near Palomares, Spain has been recovered today and will be transported directly to the United States. The casing was intact. The weapon was located on March 16 in 2,500 feet of water, approximately five miles off shore by the submersible Alvin. Photographs taken at that time tentatively identified the object as the missing weapon. The recovery of this weapon brings to a close the search phase of the operation. No release of radioactivity into the coastal waters has occurred. All wreckage fragments and associated aircraft material of interest to the accident investigation have now been located and recovered.

The Navy agreed but pointed out two corrections to be made. First, the weapon was located on 15 March, not 16 March; second it was located by units of Task Force 65 rather than by Alvin alone. The Embassy changed the one sentence to read:

> ... The weapon was located on March 15 in 2,500 feet of water, approximately five miles off shore by units of Task Force 65 ....

The statement was then approved as the final release on the bomb episode and given to the press at a conference the day after the bomb recovery as the ninth, and last, release.

THE FINAL ACT:

Both the contingency statement and the plan were utilized for publicity of the bomb recovery operation. The weapon was recovered at 0740Z, 7 April. According to one newspaper, they were told:

> The United States Embassy, Task Force 65 and the 16th Air Force are delighted to announce that the long-missing bomb was recovered safely this morning.

They were then informed that additional information would be available and that the bomb could be seen the following day.

The next day, 8 April, about 100 newsmen and photographers were ferried to the flagship (USS Albany), and were allowed to photograph the bomb. The submarine rescue ship, Petrel, slowly passed down the starboard side of the USS Albany, and then reversed course, coming within 35 yards of the flagship. The weapon was visible on decks where it lay on wooden chocks. After that Admiral Guest met with the press in a lounge of the USS Albany and gave a briefing on the recovery events. This was followed by a question-answer period, and the newsmen were then returned to shore. On the dock at Garrucha, Ambassador Duke gave a brief impromptu talk on the events.

This officially ended the bomb story from Palomares. A few days later a joint communique prepared by the State Department, DOD, and AEC was issued on guidance for publicity of nuclear weapons. Essentially, return to the former policy on these bombs was directed; nothing could be said about them, and no more pictures could be taken by the public. As far as the Palomares bomb was concerned, all that could be said was that "the weapon upon return to the United States will be delivered to a facility of the Atomic Energy Commission."

PHOTOGRAPHY:

Photography at the site by reporters was not permitted unless the person was accompanied by a military escort, and then only if they had Spanish press credentials. Some newsmen did utilize long focal length lens but generally photographs taken in this manner were not of good quality due to the high winds and dust in the area. Both the Guardia Civil and the Air Police enforced these rules.

By the end of January permission was requested for blanket approval to release unclassified photographs of the clean-up and Navy operations, following coordination with the Embassy, JUSMG, and the Spanish. It was also suggested that unclassified motion picture footage, being accomplished by U.S. Air Force photographers, be cleared for television use in the United States and copies of that material then released for submission to Spanish television through the GOS. At the same time the Navy was asked to furnish unclassified photographs for clearance, and a week later Admiral Guest told General Wilson that approval had been given for him to furnish them. On 12 February, DOD approved release of unclassifed pictures with the same policies as set down for news items; clearance with JUSMG, Embassy, and the GOS. This policy, in general, was that sound judgment was to be used to eliminate possible controversial subjects. Such things as protective clothing, radiation detectors, or anything that suggested a potential hazard could not be used.

On 12 February, photographs were given to JUSMG and the Embassy for clearance, and the Embassy passed them along to the Spanish. On 16 February, the GOS released the 14 pictures to two news agencies, EFE and CIFRA, without giving them to American or other agencies. USIS and JUSMG asked that copies be made available for others, and the 16AF provided them. The Embassy then discussed the situation of what appeared to be preferential treatment of the Spanish press and the decision was made at GOS-Embassy level that in the future all photo releases would be made by the Embassy, after approval by the Spanish. The 14 pictures given out at that time were:

1. General Wilson addressing the people of Palomares;
2. Submersible Alvin close-up with cables attached;
3. Alvin in well of LSD, cables attached;
4. Alvin in open end of LSD, man sitting on conning tower;
5. Aluminaut in open well of LSD;
6. Aluminaut under tow, ship in background;
7. Deep Jeep on ship, clear of deck, several sailors surrounding vehicle;
8. Deep Jeep on deck, several sailors in picture.
9. Deep Jeep being hoisted from water;
10. Frog man jumping into water from rail of vessel;
11. Frog man with air cylinders in rubber boat with other sailors;
12. Deep Jeep in water, frog man attaching line;
13. Tug hoisting large wing section from water;
14. Wing section in landing craft, salvage yard in background.

Pictures were released from Madrid since the major wire services all had bureaus in Madrid, and there were no facilities for transmission of photographs from the accident scene.* The photographs were reproduced at the base photo laboratory at Torrejon; for those chosen at the site (and then sent to Madrid for coordination) the Navy usually reproduced the cut-lines.

The next set of photographs was sent to USIS for transmittal to the Spanish on 21 February. Of the ten submitted, six were cleared, both by GOS and the Embassy, and were given out on 23 February:

1. Staff at the site: Maj Gen Wilson, Gen Montel, Rear Admiral Guest, and Colonel Alfaro (Commander, San Javier Base);
2. Mr. Jon M. Lindbergh leaving the Perry Submarine (PC-3B) after a dive;
3. Hoisting the PC-3B after a dive;
4. Hooking the PC-3B in preparation to hoisting;
5. Spanish and Americans working together to sort wreckage;
6. U.S. Navy landing craft pushing a lighter filled with aircraft wreckage.

The uncoordinated photographs showed military pay day with a pay-line in a tent, and shots of personnel at a party given by the airmen for local children.

In addition, the U.S. Navy issued photos of their operations, including pictures of various vessels on the scene, the submersibles being used, and activities of the divers. These

* When DOD gave permission to release photos, they said: "16th AF is authorized to release to the press unclassified photography which depicts Navy and Air Force operations at Palomares." This sentence can be interpreted two ways: (1) "to release ... at Palomares," or "depicts ... operations at Palomares." The 16AF interpreted it in the first manner and thus queried DOD asking permission to release at both Madrid and the site. SAC said that the manner of release could be determined locally providing all clearances were effected.

were cleared through the same channels as the U.S. Air Force photographs. On 24 February, thirteen were given clearance and all were released except one. Then, when the shift in release policy occurred in early March, DOD said that photograph release was authorized if the Embassy was kept informed and had no objections. In line with that, the Embassy told the site that the barrel operation could be photographed except for the filling of the barrels at Site #2, where exposure to radiation might occur. Thus, the arrival and departure of the drums could be photographed.

Permission to photograph the bomb after recovery, a completely unprecedented action, was given on 26 March. As described earlier, press representatives photographed it freely, and one underwater picture was released as well as one taken shortly after its recovery which showed the parachute still attached, with Spanish and American officials inspecting it.

HANDLING OF NEWS PERSONNEL

As may be realized from the discussion of the release problem, the main thing that information officers had to do was to be able to repeatedly say "no comment" without showing irritation. Then it was not a matter of just keeping reporters away from the hot spots, it was also necessary to just simply keep them away from where most of the activity was occurring, the decontamination sites and the naval operation. As mentioned earlier, it was not until nearly 2 months after the accident that they were really taken into the camp and Navy area, and not until 29 March was a group taken in a helicopter to view the scene. External security of the area was essentially the responsibility of the Guardia Civil, and at times tempers of the newsmen grew short. On 9 February, immediately after the British stories, written in a most flagrant scare theme, appeared in the press releases, the Guardia increased their area in which an escort was required, and the information officer at the site reported that:

> Guardia has also widened the area in which escort is required. Newsmen must now have a military escort anywhere in the crash area, decontamination area, town of Palomares, and the military encampment. This will probably reduce the information newsmen can gather, and may result in more fabrications.

He also said that British reporters had been "particularly abusive" in response to the "no comment" answer to questions, and had made comments on "information released by high officials in the British Ministry of Defense" when refused permission to talk to General Wilson. On the following day seven English newsmen were denied entry because they did not have permits from the Ministry of Information, and were told that it would take up to two weeks to obtain them. The Commander, Guardia Civil, said that their instructions were not to admit people who did not have permits, and while such a paper had been required for more than a week it had only been within the last few days that it had been asked for by the Guardia. All of the restrictions did not always apply to all newsmen, and thus appeared to be retaliation actions against sensational stories. This ban continued for several days, being reported through 16 February.

An indication of the media treatment of the accident and subsequent search activities can be gathered from some of the headlines which introduced news articles. Examples are:

20 Jan 66	U.S. ADMITS DOWNED B-52 HAD A-DEVICE
21 Jan 66	"SAFE" A-BOMB MISSING IN SPAIN PLANE CRASH
22 Jan 66	CONTAMINATION REPORTED AT AIR CRASH IN SPAIN
24 Jan 66	SONAR FIND SPURS HUNT FOR A-BOMB IN SEA OFF SPAIN
24 Jan 66	SILENCE VEILS A-CRASH FINDS
24 Jan 66	BOMBER CRASH STIRS RADIOACTIVITY SCARE
25 Jan 66	SPANISH FEAR A-BOMBER CRASH MAY HAVE DAMAGED CROPS
25 Jan 66	SPANISH FARMERS SUFFER
28 Jan 66	SUBS REPORTED GOING TO A-HUNT SITE
29 Jan 66	SPAIN BARS ATOM FLIGHTS AS U.S. HUNTS BOMB
30 Jan 66	A-BOMB LOSS WILL PERIL RIGHT TO OTHER BASES
31 Jan 66	SECRECY SHROUDS URGENT HUNT FOR MISSING A-WEAPON
5 Feb 66	MADRID POLICE DISPERSE MOB AT U.S. EMBASSY
7 Feb 66	STILL LOOKING
8 Feb 66	U.S. DENIES "THUNDERBALL" REPORT (RANSOM FOR STOLEN BOMB?) 007 IN BOMB HUNT? U.S. REPLY: O, O, NO!
9 Feb 66	CHARGES NEAR CATASTROPHE FROM U.S. BOMB SOVIETS SAY "NUCLEAR VOLCANO" IN SEA OFF SPAIN
19 Feb 66	SOVIET ASKS WORLD CHECK ON U.S. H-BOMB OFF SPAIN
20 Feb 66	PALOMARES LEARNS TO LOVE THE BOMB
25 Feb 66	U.S. FACES UNENDING CLEANUP TASK
27 Feb 66	FORTY DAYS AND STILL NO BOMB; U.S. LEADERS SILENT
27 Feb 66	U.S. MAY NEVER FIND LOST BOMB
27 Feb 66	U.S. REPLY TO MOSCOW CHARGES PROPAGANDA
3 Mar 66	SPAIN KEPT LOST BOMB SECRET
3 Mar 66	AIR CRASH SCATTERED RADIOACTIVE FUEL
3 Mar 66	ENVOY TO SPAIN WILL SWIM NEAR SITE
3 Mar 66	DEADLY CLEAN-UP TASK IN 2 AREAS
3 Mar 66	U.S. ADMITS LOSS OF NUCLEAR BOMB
Unknown	SUN OF DEATH NEARLY SETS COAST ABLAZE
13 Mar 66	A-GOOF EVIDENCE FACES BURIAL IN S.C.
18 Mar 66	MISSING BOMB IS LOCATED
27 Mar 66	H-BOMB RECOVERY IS SNAGGED AGAIN
7 Apr 66	H-BOMB IS RECOVERED
13 Apr 66	PALOMARES SNAG: SETTLING CLAIMS

ANNIVERSARY ACTIVITY

As the first anniversary of the accident approached, there was recognition that press interest would be revived. Contingency guidance for press interviews was prepared and issued to interested U.S. agencies. The format was generally one of question and answer. Subjects which were recognized as being of continuing interest were covered. Among these were: claims, radiation exposure tests, crop conditions and tourist activities.

During the second anniversary, the BBC television became interested. The coverage included the role of the U.S. Embassy, claims, radiation exposure and United States and Spanish relations.

Near the fifth anniversary, Helsinki's ILTA SANOMAT published a very damaging article, the gist of which was that the rich United States had left poor Palomares in a continuing tragedy. The article described Palomares as the third victim of the atomic age, after Hiroshima and Nagasaki.

The Embassy in Madrid requested that a CBS correspondent then in Madrid and who had also been in Palomares in 1966 covering the accident, make a then-now comparison of conditions. His survey denied in every case the inferences and allegations of the ILTA SANOMAT story.

SECTION 7

SUBSEQUENT BIOMEDICAL AND ENVIRONMENTAL FACTORS

The fact that Junta de Energia Nuclear (JEN) personnel were present and worked with U.S. personnel during the clean-up operation was covered in Section II. The first bio-assay samples of Palomares residents were taken a few days after the accident. No unreasonable levels were encountered.

It is reasonable here to include portions of Dr. Wright Langham's progress report on the JEN's activities written on the occasion of his last visit to Spain in November 1971. It contains the most up-to-date summary of the follow-up program:

> An agreement between the U.S. and Spanish Atomic Energy Commission set up a four-point follow-up program to the Palomares incident. The program was to be strictly under the direction of the Junta de Energia Nuclear's Division de Medicine y Proteccion (Dr. Eduardo Ramos) with equipment, technical help, and operational support from the U.S. Atomic Energy Commission. The four-point program was as follows:
>
> (1) Collection of information on uptake and retention of plutonium and uranium by representative numbers of a population group potentially exposed to inhalation of a plutonium oxide aerosol.
>
> (2) Measurement of temporal and seasonal fluctuations in plutonium air concentrations above a plutonium oxide-contaminated agricultural area that has been subjected to the agreed upon decontamination procedures.
>
> (3) Serial measurements of contamination levels (both by plant uptake from the soil and wind dispersal) of agricultural products produced in a contaminated area subsequent to decontamination.
>
> (4) Studies of the temporal migration and redistribution of plutonium oxide in soil, decontaminated by deep plowing, as a result of continued cultivation and weathering.
>
> Technical assistance, approximately $250,000 in equipment (including whole-body and lung counter), and annual operating funds to the extent of about $25,000 per year, have been provided by the U.S. Atomic Energy Commission to support the effort.
>
> Six or so unclassified papers have been prepared addressing the Palomares incident. These are largely general in scope and difficult to find. Records show the following articles:

(1) William D. Moss: Report on Bio-assay Laboratory in Madrid, Spain, Los Alamos Scientific Laboratory Report H5MR66-1 (September 1966).

(2) Eduardo Ramos Rodriguez: Palomares Two Years After, presentation at some European conference, publication not known.

(3) Emelio Iranzo: First Results from the Programme of Action following the Palomares Accident, Symposium on Radiological Protection of the Public in a Nuclear Disaster (IRPA), Interlaken, Switzerland (June 1968).

(4) E. Iranzo and E. Ramos: Measures to Determine the Risk to which a Population can be Subjected as a Result of a Nuclear Accident Generating Radioactive Aerosols: Environmental Contamination by Radioactive Materials, International Atomic Energy Agency, Vienna, Austria (1969).

(5) C. Alvarez-Ramis and Gregorides de los Santos: Contamination de Gasteropodes Terresteres Habitat un Biotope a bas Niveau de Contamination Alpha Due Plutonium et a l'Uranium, Actes du Symposium International de Radio-ecologie, Centre d'Etudes Nucleaires de Cadarache du 8 au 12 (September 1969).

(6) Emelio Iranzo and Sinesio Salvador: Inhalation Risks to People Living near a Contaminated Area, Second International Congress of the International Radiation Protection Association, Brighton, England (May 1970); not published.

All primary data collected to date relevant to the four-point program was available in Madrid. Under point one, 100 of the most likely exposed residents of Palomares were taken to Madrid and counted in the lung counter. The lower limit of detection of the counter was approximately 40 nCi. No positive counts were observed in any of the 100 individuals. The counter was modified by the Spanish to give a minimum detectable limit of about 16 nCi, and a few of the most likely exposed individuals were recounted. Even with the improved sensitivity, no positive counts were observed. Urine samples (24-hour) were collected from the same 100 individuals. Seventy-one percent of the subjects showed no indication of plutonium in the urine. The others showed urine values of less than 0.1 to 0.2 disintegrations per minute per 24-hour sample -- not statistically significant. It is my understanding that no further measurements have been made on the Palomares residents.

Point two of the agreement (measurement of air concentrations) was initiated with installation of four continuous air-monitoring stations and two meteorological stations strategically located with respect to the contaminated area. One of the air-monitoring and meteorological stations was located in the center of the village. Continuous air monitoring at all four stations were continued for approximately 2 years. Daily samples were counted for gross alpha activity, and 10-day samples were pooled and analyzed for plutonium using chemical separation and alpha

spectrometry. Uranium-234 and uranium-235 were detected in the air samples taken in 1967. These results were reported in the paper by Iranzo and Salvador (paper No. 6 in the previous listing) at the Brighton International Congress.

Positive air samples were obtained occasionally at all stations, with the highest values coinciding with periods of high wind velocity (above 35 km/hour). Mean plutonium values in the village for 1966 and 1967 were 0.38×10^{-15} and 0.09×10^{-15} $\mu Ci/cm^3$, respectively. Only the air sampling station in the center of the village (station P) and the one in the irrigated fields to the east (station 3-2) are currently in operation. The others have been discontinued and salvaged to obtain parts to keep the other two in operation. Judging from sound, they are about ready to go also. In my opinion, it is unfortunate that station 2-2, strategically located to sample wind pickup from the untreated hillsides, has been discontinued.

With regard to point three of the agreement (plütonium in vegetation), periodic sampling has been conducted. Reported measurements to date are in terms of gross alpha activity. They now have alpha spectrometry data on most of the vegetation samples. The Palomares area is perhaps one of the highest natural alpha background areas in Spain. The number of samples to be processed is large, and the Spanish were given only one alpha spectrometer which has given poor service. Counting times for spectral measurements are long, and air samples alone have been taking most of the available instrument time. Alpha spectrometry analysis of all samples (air, vegetation, ans soil) will be required before the actual plutonium contamination can be established. The gross alpha and plutonium measurements of vegetation are characterized by great variability from area-to-area and from sample-to-sample within the same area. Undoubtedly, this variability is a manifestation of the difficulty of representative sampling and the nonuniform particulate nature of the environmental contamination. Contamination of vegetation appears to be almost entirely surface-deposited. Leaves and stalks run higher than the plant fruit. This is especially true for tomatoes. In general, natural vegetation runs much higher than cropped vegetation. Natural vegetation is usually confined to the hillsides, where plowing under of the plutonium was not practical and many of the plants are perennials. In 1969 and 1970, esparto grass (near impact point No. 2, area 2-1) ran 9063 and 10,314 pCi of plutonium/kg wet weight, respectively. Esparto is a tough perennial that grows from a crown of dead growth from past seasons. The crown appears to be an excellent filter for trapping moving particles. Artemisa from the same area ran 3861 pCi/kg. In 1969 alfalfa from area 5-2 ran 41 μCi/kg. Vegetation from the western side of the village usually runs higher than the same vegetation from areas in and east of the village. When alpha spectrometry data are complete, a summary of the vegetation analyses may show some interesting correlations with the levels and methods of cleanup. The article by Alvarez-Ramos and Santos (No. 5 of the previous list) gives considerable data on gross alpha activity of vegetation in the Palomares area during 1967 and 1968. Work has been done on gross alpha activity of snails, etc.

(gasteropodes) from the area. Activities were very low. Fish samples from Garrucha, a fishing village near Palomares, showed no measurable activity.

The soil studies program (point four of the agreement) is a slow, arduous task fraught with many difficulties, the greatest being the representative sampling problems. Analytical variations among samples are quite high. Six sampling plots, strategically located through the contaminated area, were laid out by Dr. Eric Fowler of Los Alamos. These are sampled annually in depth increments of 0-5, 5-15, 15-25, 25-35, and 35-45 cm. Surface samples are taken at several points in each plot. The vegetation samples are taken also from or near these plots. So far, the soil analyses are as gross alpha activity per gram. Alpha spectrometry analysis of the samples is just beginning.

In general, the relative depth distribution of activity is about as one would expect from the plowing operation. It is doubtful that one will see any significant redistribution with time because of inherent large statistical variations and low rainfall. One time variation that concerns the investigators has been noticed. The surface layer of the plowed areas near the hillsides that could not be plowed is increasing in activity with time. This is interpreted as resulting from movement and redeposition of plutonium from the hillsides and shows that plutonium deposited on the surface is indeed moving with the winds.

Manuscript material and tabulated data are in various stages of preparation for publication as a special issue of the Junta de Energia Nucleaire's Journal, Energia Nuclear, an impressive, slick-paper bimonthly publication. The articles will cover the following subject matter: (a) bomb physics and phenomenology (Pasqual); (b) general description of the accident (Ramos); (c) physiology and toxicology of plutonium (Ramos); (d) plutonium in soils (Iranzo); (e) plutonium in vegetation (Iranzo); (f) plutonium in air (Iranzo); and (g) summary. They are hoping for publication of the special issue by mid-1972. However, they do not work fast, and their very limited staff seems overcommitted because of pressures of other problems. Dr. Iranzo particularly seemed disturbed about rushing publication when much of the desired alpha spectrometry data are incomplete but believes they should go ahead as fast as possible with publication.

Some of their equipment is now obsolete and their facilities still poor by U.S. standards. The equipment we gave them is now 6 years old. It has not been updated, improved, or added to.

Enthusiasm for the work did not seem as high as it once was. This could be a result of their having to turn their attention during the last year to a fission-product release into a major river used for irrigation of vegetable crops for the Madrid market. It could be also that we have not maintained the interest and attention in the Palomares program manifested originally. Limited foreign travel funds prevented return for 6 years.

They are understaffed technically and depend a lot on use of graduate students supported by the $25,000 per year operational support from the U.S. Atomic Energy Commission.

Current concern in this country over plutonium environmental contamination from the breeder reactor developmental program and from projected uses of plutonium-238 might justify considering revitalization of the Palomares program. One might consider the following actions:

(1) Encourage them to get on with publication of their observations to date.

(2) Increase operational support to provide more technical staff.

(3) Update their equipment and certainly provide at least one additional alpha spectrometer.

(4) Reevaluate their approaches to the four points of the agreement and modify them as indicated by the past 6 years of experience and the accumulated data.

(5) Consider the advisability of providing them with a new lung counter to recount a number of the 100 Palomares residents examined the first year after the accident. Counters are now possible with a minimum detectable limit of 4 ± 4 nCi of plutonium; their sensitivity to americium-241 is 100 times greater. Results on people who have lived in a contaminated area for 6 years after an accident might be of value even if all negative -- as I am relatively certain they would be.

(6) Manifest more interest in their work through more review of their efforts.

In a recent visit (April 1973), Dr. Emelio Iranzo of the JEN indicated an interest in revitalizing the Palomares studies. In general, he is in agreement with the recommendations made by Dr. Langham in his trip report. One exception might be the inadvisability of a new lung counter. It is doubtful that such an installation would represent an efficient investment over their present equipment.

Unless the political implications of a continuing radiation monitoring program at Palomares are overriding, a program such as Dr. Langham and Dr. Iranzo propose should probably be supported. Palomares is one of the few locations in the world that offers an on-going environmental laboratory, probably the only one offering a look at an agricultural area.

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SECTION 8

EPILOGUE

THE DESALINATION PLANT:

In the latter stages of 1966 consideration was given to some means of recognizing the people of Palomares for "the help given ..., in some cases at considerable personal risk, in the initial rescue of survivors from aircraft crews, of their cooperation in subsequent clean-up operations and in prolonged and anguished search for the missing bomb, and finally, of the traumatic disturbance to their daily existence represented by the accident." By December 1966, a suggestion that the United States offer the people of the Palomares area a desalination plant to treat the area's plentiful but saline ground water had received some support in Washington. An effort was made to obtain approval for the project prior to the first anniversary of the accident. Such an action would have blunted the "bad press" which U.S. and Spanish authorities were expecting.

By June 1967 some opposition to the plant was apparent within U.S. agencies. This opposition was verbalized by suggesting that desalination plant would be the subject of adverse propaganda, implying that the accident contamination had affected the local water supply and that the water now required some treatment. A counter-proposal of a school/community center was suggested.

Preliminary to an October 1967 meeting with the U.S. Secretary of State in New York City, the Spanish Foreign Minister, Fernando Maria Castrella, made it known that the Spanish knew of the gift project and that they would prefer the desalination plant. At the same time he scoffed at the adverse propaganda issue.

Several analyses to define parameters of a desalination plant were undertaken. However, by January 1968, we find that another negative aspect appeared. The argument was that the Palomares ground water had been getting more saline (seepage from the sea) each year, and was already beyond being satisfactory for agriculture. As the area depended upon agriculture for its existence, and as a desalination plant of the capacity being suggested could not support agriculture, there was a feeling that we would be building a "monument to our own lack of foresight."

In March 1968, the U.S. Embassy officially advised the Spanish Government that the United States would support a desalination plant in the Palomares area to the extent of $150,000. Spanish review of the proposal concluded that the unit cost of the water thus provided would be too high. At the same time the Spanish recognized their responsibility to the area and countered with a proposal to enter into a larger scale, joint desalination project which would provide lower unit costs and supply more villages in the area. By this time a decision had been reached to use sea rather than well water as a source for the plant.

In June 1968, a formal note was presented to the Spanish Minister of Foreign Affairs by the U.S. Charge d' Affaires of the Madrid Embassy. It recognized the project as a joint U.S./ Spanish effort with the previously mentioned U.S. support of $150,000. The U.S. funds would be applied toward the plant itself, while the Spanish would be responsible for land acquisition, storage, conduction and distribution systems. The plant contract was let to a U.S. firm (Aqua-Chem, Inc.) and amounted to $427,272. In addition to the Spanish share of this plant cost ($277,272), the GOS also supported the distribution system (one estimate is $500,000, or slightly lower).

The completion date was originally slated for late 1971. A number of problems were encountered (low water volume from beach wells, higher than normal alkalinity of well water, etc.). These problems caused delays. The 30-day acceptance test was completed in February 1973. Discrepancies resulting from the test had been corrected and a short test of 5-10 days is scheduled. At this time, Palomares is the only village to which the distribution system (a Spanish project) has been completed.

CONCLUSION:

What is Palomares? To the Spanish people who live there, it is their home and it provides their livelihood. To them, it is no different than Atlanta or Portland or Washington, D.C. - it is home. It is a home that many thought they had lost on a clear winter day when it rained fire, and metal and Radioactividad. To the Government of Spain, it is now a familiar village in a part of Spain with a considerable potential for attraction of tourists, a growing industry in Spain. To the U.S. government, it remains as the site of a tragic and embarrassing accident which held the attention of the world for a few long months in 1966. To hundreds of men of the U.S. Armed Forces civilian members of the atomic community, and contractors and consultants, Palomares is a remembered portion of their lives. To some, it is long hours spent stooping over fields and rocky hills with an alpha counter. To others, it represents that catch of time that the city boy-aircraft technician spent as a farm worker, a reaper of wheat, a tomato picker. To still others, it is long hours at the wheel, holding a ship in an exact location in howling winds that fought against their efforts. It is working at the limits of human and machine endurance 2,500 feet below the surface of the sea in precipitous underwater canyons, eyes ever-straining for the sight of that needle in the haystack.

But what was Palomares? What did we learn there? We learned something of the scope of decontamination operations after a nuclear weapon accident - the man hours, the materials and their deficiencies, the knowns and the unknowns. We learned a great deal about deep water salvage, about finding that needle in the haystack. We learned some more about people - about their needs and their capabilities. We discovered some of the difficulties of a large scale claims operation. We saw the smiles and undeserved gratitude of people who had been treated fairly, and we saw the diplomatic and propaganda impact of those who felt that they were treated unfairly. We learned that a common need of all men; the atomic scientist from Los Alamos, the General from SAC, or the farmer from Palomares - yes, even a news reporter; is to understand the unknown, and exactly what that unknown means to him as an individual.

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This document begins with a dedication to Dr. Wright Langham. It seems fitting that it should end in his own words. They are taken from a trip report of his last trip to Palomares.

I cannot resist one more casual comment. Tourism has become Spain's largest industry. Last year they had 25 million tourists, while the total population of Spain is only about 35 million. During the 1966 negotiations with high Spanish officials, their great concern was that the nuclear weapon accident and residual plutonium would interfere with promotion of tourism in this region of the Costa Blanca -- as was occurring throughout the Costa Brava and Costa del Sol. The latter regions of the Spanish Mediterranean coast now look like Miami Beach crowded with high-rise apartments and luxury tourist hotels. The idea that the bleak, isolated region around Palomares and Mojacar would ever be developed for tourism seemed so incongruous at the time that it was my opinion they were using the issue only for bargaining purposes.

During the return visit to Palomares, I stayed in the government-owned Parador Motor Hotel (only 12 miles from where the bombs fell) with dining room, bar, and rooms with a balcony and picture windows overlooking the Mediterranean. Only 5 miles from the Parador in Mojacar (a glistening white Moorish village on a mountain top, steeped in history back to 2000 B.C. and the birth place of Walt Disney) is a fabulous luxury hotel designed by a Madrid architect. The architect, saw from the window of his apartment in Mojacar the explosion that released the bombs over Palomares. He claimed to have rushed to Palomares and sustained a radiation burn to his knee while inspecting one of the bombs in its crater. He became very concerned that he had been contaminated by plutonium and injured by radiation. The JEN Division de Medicine y Proteccion, after much counciling and examination, was able to allay his fears, and he completed his designs of the Hotel Mojacar. Perhaps someday ___ _ his fabulous hotel, and the nuclear weapons accident over Palomares will become just another of the many legends to tell visitors to the ancient and spectacular village of Mojacar on the Costa Blanca.

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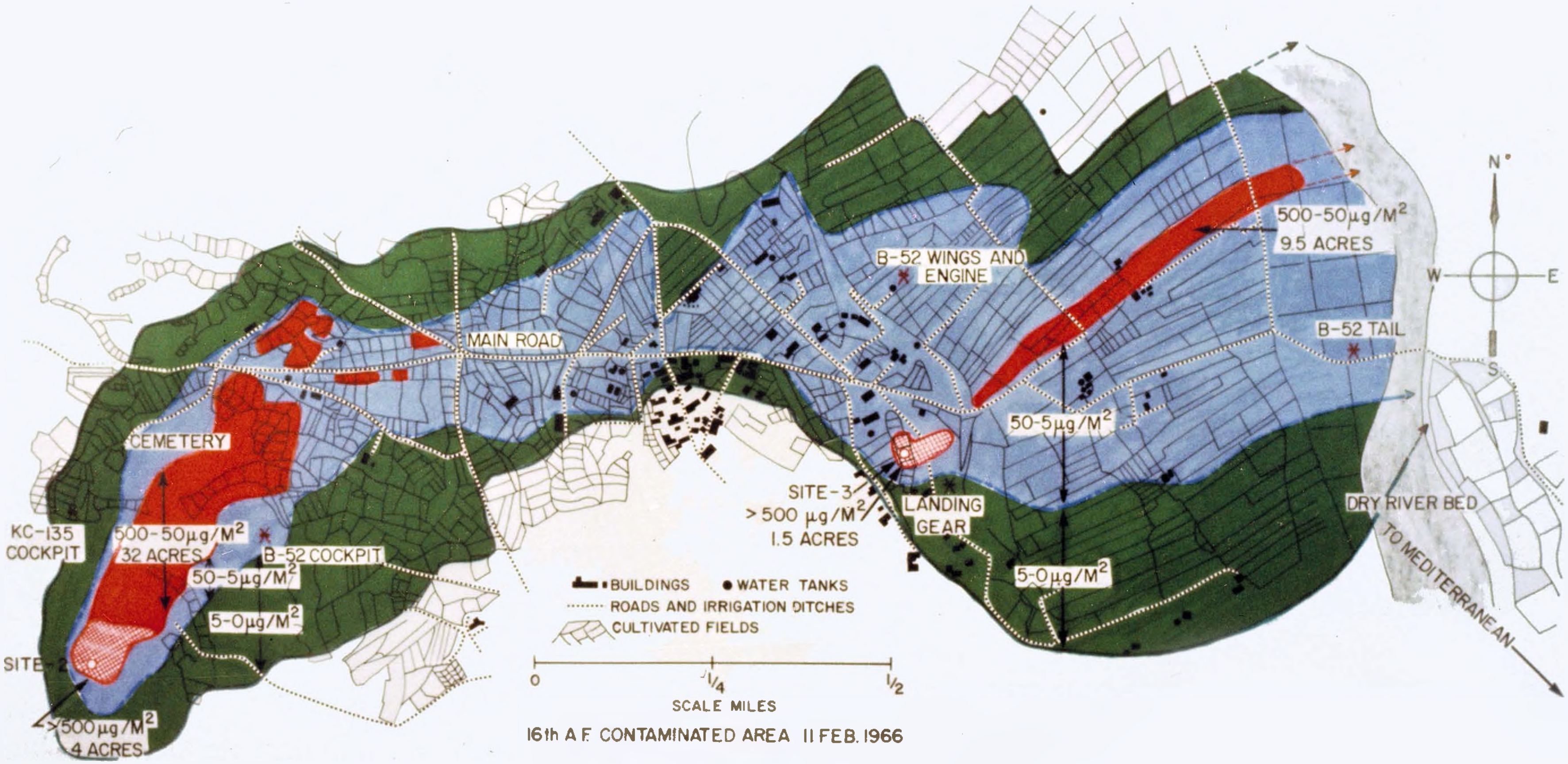

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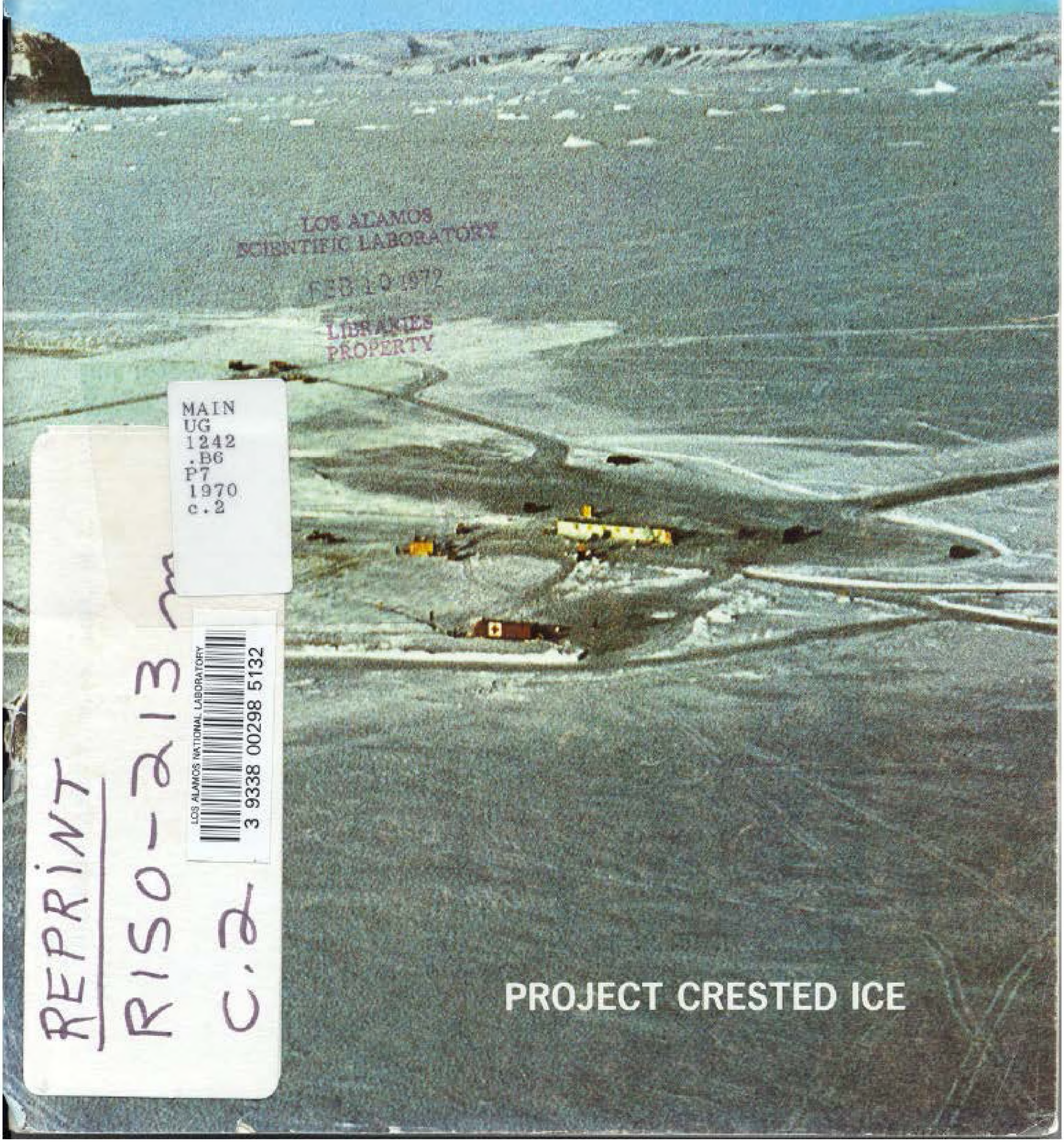

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FOREWORD

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GREAT technological accomplishment imposes great responsibility. Nowhere is this responsibility made more apparent than when an accident involving an advanced development poses a possible threat to people whose only involvement is that of proximity to the scene of the mishap. A potential catastrophe tests—as nothing else will—the desire to cooperate, to exert exceptional effort, and to devise new measures for averting disaster.

Our nuclear weapons can be activated only after a prescribed sequence of actions is followed. Because of their awesome destructive power, however, any accident involving them rightfully receives maximum attention. On January 21, 1968, a B-52 bomber carrying four nuclear weapons crashed on the sea ice off the shore of Thule, Greenland. Both the aircraft and the weapons disintegrated on impact. There was, of course, no nuclear explosion since the design of the weapons precluded any nuclear reaction. Nevertheless, limited contamination resulting from the dispersed radioactive material from the weapons had to be controlled and removed, as did the aircraft debris.

A major disaster was turned into a classic example of international cooperation at governmental, scientific, and local levels. During the ensuing months, the Danes and Americans at Thule provided a striking example of international teamwork. The seemingly insurmountable task of recovering and removing all traces of the accident proves again that truth may be stranger than fiction—and fully as exciting. This issue has been chosen to provide a condensed but complete summary of details of this true modern saga of international cooperation—by the people who were there.

MAJ GEN RICHARD O. HUNZIKER, USAF Retired

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HQ STRATEGIC AIR COMMAND
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The Flight

SUDDEN AND UNEXPECTED DANGER

ON 21 January 1968, HOBO 28 took off on a 24-hour airborne alert mission. At the time of lift-off there was every indication that the mission would be completed successfully. All required maintenance and aircraft inspections had been performed. A later examination of all aircraft records and related documents revealed no signs of maintenance malpractices or system discrepancies that would bring on an accident. The crew of HOBO 28 was an integrated combat-ready crew; that is, its members had continually trained and flown together as a unit. An extra pilot was aboard to insure adequate rest for the principal crew.

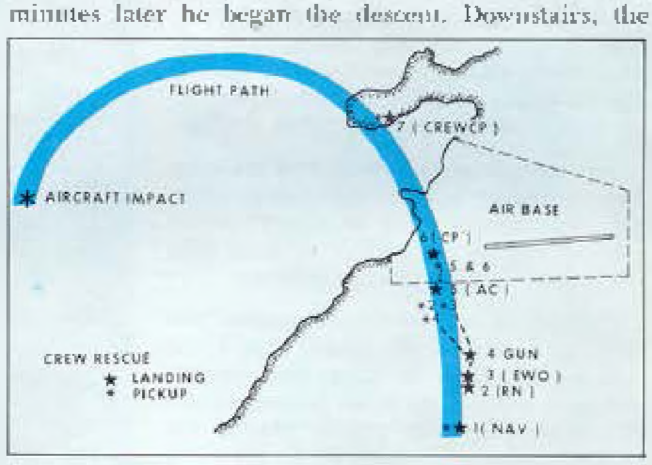
Following take-off, the flight proceeded uneventfully. The first aerial refueling, accomplished approximately 4 hours into the mission, was routine. One hour later the aircraft commander instructed the crew-assigned copilot to begin crew rest and ordered the spare pilot into the copilot's seat. At this moment in a most unobtrusive way started a series of events that led to the destruction of HOBO 28.

The cabin temperature became too cool for comfort at the flight-planned altitude. In accordance with approved procedures, the substitute copilot selected the emergency right-hand inboard position to provide cabin air and rotated the temperature rheostat to the position of maximum heat. This action provided a source of very hot air for cabin temperature control. After making the initial setting, the copilot began decreasing the rheostat setting as crew members on station reported they were getting too hot. Then, a few miles south of a northern air base, one crew member detected and reported the odor of burning rubber. With fumes growing stronger in the cabin, the aircraft commander instructed the crew to go on oxygen and attempt to locate the source of danger. The copilot repositioned the air bleed selector back to the normal position.

IN-FLIGHT FIRE

The navigator searched the lower crew compartment once without finding where the smoke and fumes were coming from. Ordered to make a second search of the same area, he moved a metal box, and located the fire. Hurriedly he alerted the crew and started using a fire extinguisher on the flames.

The pilot notified the ground station of a fire in the cabin and requested authority for an immediate descent and for emergency landing at Thule Air Base. Two minutes later he began the descent. Downstairs, the



Crash path prior to impact on the ice.

# of Hobo 28

navigator was having little success in containing the fire even though he had now used both available fire extinguishers. Shortly after the descent began all aircraft electrical power was lost, and the bailout order was given and executed. The aircraft continued on down, struck the ice intact in a steep left bank and disintegrated from impact, explosion, and fire.

ESCAPE AND RESCUE OPERATION

Seven persons were aboard the aircraft. Six survived.

Pilot. The pilot was wearing thermal underwear under a winter weight flying suit. Having given the bailout order, he reached down and turned on the abandon light and heard in short succession four distinct explosions from ejection seats. He could not now see anyone on the upper deck, but he could see the glow from the fire on the lower deck. He rotated his ejection levers. His next sensation was that of floating down in his parachute. He could see lights, and he actually landed within the confines of the air base below. After landing, he attempted to open the survival kit, but it was so dark and his hands so cold that he could not. Abandoning the chute and survival kit, he walked about 600 yards to a heated hangar on the air base.

Copilot. The spare pilot occupying the copilot's seat was wearing arctic underwear beneath a summer flying suit. As the emergency developed, he put on his parka. He describes his ejection as not painful or unpleasant. After his chute opened, he deployed the survival kit and adjusted himself for landing. He found that he was directly over the west end of a runway. As his feet touched, he yanked the quick-disconnect mechanism and struck on his right thigh and side. Safely on the ground, he could find no injuries and proceeded about 200 yards to a hangar. Personnel in the hangar immediately transported him to the base hospital for observation.

Radar Navigator. The radar navigator remembers the lower crew compartment as a sea of flames. He also remembers a tremendous shock at ejection and a heavy opening shock from his parachute. He could not stop his oscillations beneath the chute because of an injured arm. During descent, he saw the lights of the base and a bright flash from the aircraft striking the ice. Even though he lost his helmet and left glove in the ejection, he does not remember being overly cold during the descent. By the time he was able to detect the ground, he was only 20 feet above the surface, and he hit without deploying the survival kit. After landing, he was concerned that his injury might get worse, so he hurried on without attempting to open his survival kit. He had gone only a short distance when he was joined by the crew Electronics Warfare Officer (EWO).

Electronics Warfare Officer. The crew EWO was wearing thermal underwear under a light summer weight flying suit. He was not wearing a winter parka and had no time to don it before ejecting. When ordered to abandon the aircraft, he went through his ejection sequence and next remembers the cold night air. While descending, he noticed that he was drifting away from the base. This did not cause him any great concern because he felt that he could make it to the base on foot anyway. The snow felt like concrete when he hit. His attempts to open the survival kit failed because of the cold. He

heard a cry for help. In the course of answering, he managed to rendezvous with the injured radar navigator. He returned to his kit and got out some of its contents to make the injured man more comfortable. Together they started for the base. After traveling for 30 to 45 minutes, they were rescued by helicopter.

Gunner. The gunner was also wearing thermal type winter underwear under a summer weight flying suit. After hearing the bailout order, he ejected without incident except that he lost his helmet and gloves. He felt that the descent took an extremely long time and because his hands were cold, he did not deploy the survival kit. After landing, he attempted to open the kit but the intense cold stymied his efforts. Since he could not see the air base, he soon abandoned the kit and started walking. An estimated hour and a half later, searchers found him and took him to the hospital.

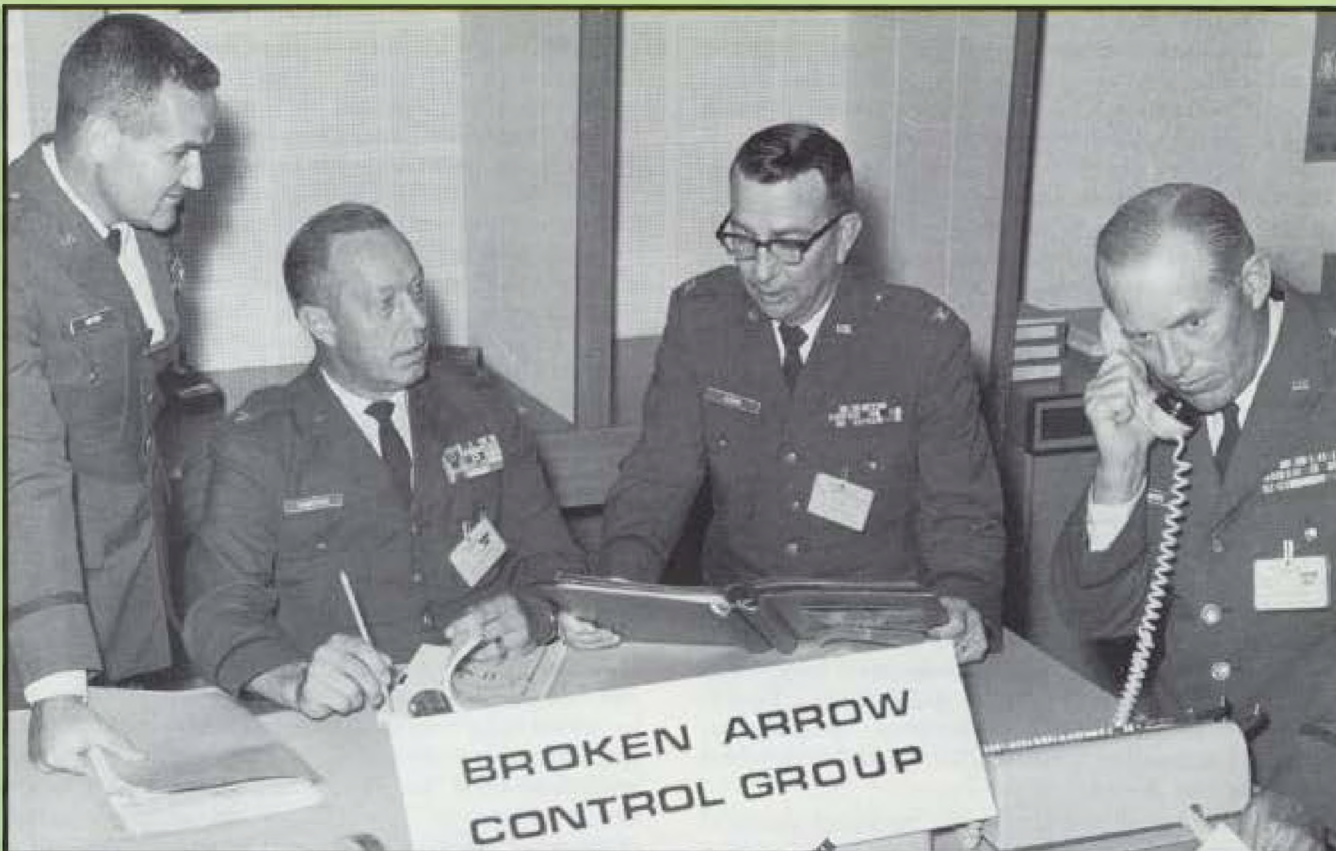
Navigator. The navigator was the first crew member to eject and the last to be rescued. During ejection, he remembers his arms flailing and the thought that his shoulder was broken. The pain in his shoulder kept him from deploying his survival kit during descent. After he landed, this same injury prevented him from opening the kit. He thought about attempting to walk to the base, but decided against it because he had lost his directions. He finally wrapped himself in the parachute and lay down on the snow to rest. Throughout the next several hours he heard helicopters flying low, some within 30 feet, but he was unable to attract attention. It was to be more than 22 hours before a search plane would locate him in a depression in the snow. He was immediately taken to the hospital for treatment of serious frostbite.

Crew Copilot. When the fire was detected, the crew copilot was out of his seat for crew rest. The rapid development of the emergency prevented his return to his primary position. Having no recourse to an ejection seat, his only other means of egress was by way of the navigator's hatches in the lower crew compartment. To get to them he had to pass through the fire area. When his body was recovered, the soles of his boots and a portion of his parachute canopy and harness showed evidence of fire damage. The cause of death was not the fire, but a head injury sustained in all probability when he departed the aircraft at the high airspeed. The rescue of the injured navigator ended the ordeal of the crew of HOBO 28 some 24 hours after takeoff.

EPILOGUE

SAC would like to avoid all aircraft accidents. The thousands of hours SAC aircraft have flown safely attests to the soundness of a program the essential elements of which are crew discipline, close and continuous supervision, and insistence upon professionalism. Nonetheless, so long as vigilance requires flying the risk of mishap remains. And accidents are notoriously disrespectful of time, place, and circumstances. SAC has, therefore, organized a team of specialists to respond anytime, anyplace to accidents and to minimize the aftereffects of such emergencies. It was this team that moved in following the crash of HOBO 28 to perform most impressively.

SSgt Calvin W. Snapp (center), Gunner, is aided by rescue personnel, TSgt Jackie D. Wanghtel (left) and Sgt Robert T. Switala, after ejecting from HOBO 28.



Broken Arrow Control Group, (l. to r.): Maj T. G. Hopkins, Operation's Staff Controller; Col O. J. Sundstrom, Team Chief; Col H. A. Cook, Jr. Safety Member; Lt Col V. E. Larson, Munitions Member.

THE THULE AFFAIR

COL O. J. SUNDSTROM
Directorate of Supply and Services
Hq USAF, Washington, D. C.

IF you happened to look at page 15 in a leading Midwest newspaper on the 10th of September 1968, you might have seen the short article in the right-hand column which said: "Thule H-Bombs Not Dangerous—Washington—The Department of Defense said Monday that scientists have found 'No danger to human, plant, marine, or animal life resulting from the crash of a B-52 bomber carrying hydrogen weapons in Greenland'." In this way Danish and American scientists recorded the results of their careful investigations.

On the other hand, if you were in the vicinity of Wholstenholme Fjord, Greenland on the afternoon of 12 July 1968, you might have seen the remains of what had marked the location of Camp Hunziker slip quietly beneath the smooth glassy water. Before that time, the contaminated ice and debris had been scraped, loaded, hauled ashore, and placed in tanks for later removal, to assure that the announced safety would be perpetuated.

The tragic crash of a B-52 aircraft on sea ice off Thule, Greenland at 4:39 p.m. Atlantic Standard Time, 21 January 1968, became the focal point of the concentrated efforts of many hundreds of people for many weeks thereafter. The reason—nuclear bombs were on board and their fate was unknown.

Minutes after the terse "flash" message was received by the USAF Command Post on that Sunday afternoon in January, the Headquarters USAF Broken Arrow Con-

trol Group was mobilized simultaneously with the activation of many lateral and subordinate disaster response organizations. This "alert force," selected knowledgeable Air Staff personnel, who serve their turn on 24-hour standby duty in addition to their regular Air Staff duties, responded within the hour. Some came from homes many miles from the Pentagon nerve center, the USAF Command Post located deep inside that building on the Virginia shore of the Potomac flats. At the same time, the Departments of State and Defense were establishing liaison with the Danish Government and scientific groups. This cooperation—in Thule, Copenhagen and Washington—was to continue from the first hours following the Thule crash through the final stages of the clean-up operation many months later.

By Headquarters USAF Office Instruction covering response to nuclear emergencies or accidents, the Director of Supply and Services, or his munitions representative, was designated as the Broken Arrow Control Group Team Chief. His team, like that of other agencies organized under nuclear disaster preparedness directives, calls on many Air Staff officers for professional and technical support as deemed necessary. Selected personnel from Systems and Logistics, Operations, The Inspector General, Surgeon General, and Office of Information typify the "first team" of required specialists.

Well developed and frequently reviewed checklist procedures which are maintained in the Command Post were brought out and tasks assigned to reporting team members as they checked in. Other governmental agencies and military service units were alerted during the initial phase of the disaster alert. Communications were promptly established with the Defense Atomic Support Agency, Atomic Energy Commission, the Department of State (and through it, the Danish Government), National Military Command Center, and Army and Navy Control Centers to advise them of the existing situation and to alert them for possible response.

As the field forces of the Strategic Air Command (SAC) and the Aerospace Defense Command mobilized and reported, situation reports began to filter in. It was soon evident that the problem was of major consequence. To prepare for the long pull, the Broken Arrow Control Group was organized into two 12-hour shifts for continuity of operation.

With receipt of information and situation reports, one time-consuming task faced by the Broken Arrow Control Group was to consolidate data and develop precise reports and briefs. These were prepared for the Chief and Vice Chief of Staff, Secretary of the Air Force, Air Force General Counsel, Joint Chiefs of Staff, Secretary of Defense, Department of State, and the White House. Other briefings and data files were prepared for the Command Post, Deputy Chiefs of Staff and offices of primary interest, as required, to implement support requirements.

Reaffirming the tried and proven policies and guidance given for nuclear emergency situations, the Vice Chief of Staff made it very clear that The Commander in Chief, Strategic Air Command, and his "On-Scene Commander" would run the show for the United States in cooperation with Danish authorities. The Broken Arrow Control Group would provide support requested which was beyond the immediate capability of the command involved, or taxed its resources so as to affect assigned mission responsibility. Matters of policy in all cases were referred to the Office of the Chief of Staff and were implemented through the Broken Arrow Control Group.

Shortly after his arrival at Thule, the On-Scene Commander assessed the dark, cold, and hostile environment surrounding his operation. As the situation developed, his frequent requests for specific types and categories of talent, tools, and equipment, which were beyond the scope of, or not available in SAC, were funnelled to the Broken Arrow Control Group for action. The requirements were researched, located, made available, and promptly dispatched to Thule.

The list reached staggering proportions and "things you never heard of before" were rounded up from the far corners of the earth. Army amphibious vehicles and prefabricated arctic buildings from Alaska, arctic ice specialists from the U.S. Army Terrestrial Sciences Center, Hanover, New Hampshire, atomic scientists and supporting technicians and officials from the United States and Denmark, and sophisticated radiological equipment from New Mexico, California, and Ohio, disaster kits from Texas and Europe, oceanographers from Navy resources, and people with a thousand talents from everywhere.

During the early weeks of search and recovery the Military Airlift Command responded to innumerable requirements to airlift urgently needed supplies, equipment, and people to and from Thule. Although heavily committed to many other top priority airlift requirements throughout the world, those valiant crews made it to Thule, as and when needed, with loads that resembled booty from an auction. SAC, of course, generated many extra flights from their own overburdened resources of tankers and base aircraft. In fact, nearly every Air Force command possessing cargo-capable aircraft lent a willing hand to support Project Crested Ice.

From the very beginning, the radioactive aspects of the accident drew worldwide attention of friend and foe alike. People remembered the sensational stories circulated after Palomares, Spain, and other instances of nuclear bombs involved in aircraft accidents. Fact, fiction, and voluble emotion were reported by some of the foreign press about the Thule crash, sometimes with the aim of discrediting the United States. Countering these erroneous and misleading stories were direct, straightforward reports of the facts, numerous on-the-scene briefings and tours conducted by the On-Scene Com-

mander and his staff, and close cooperation with Danish officials and scientists at all levels of government, who worked hand-in-hand with American counterparts in resolving the post-accident problems.

In mid-February, American and Danish scientists, government representatives, and Air Force officials reviewed the situation at meetings held in Copenhagen, and jointly planned the course of future actions. Since there was no evidence of any nuclear contribution from the destruction of the weapons involved in the accident, efforts were directed at removal of alpha-emitting particulates and aircraft fuels which could contaminate the Thule coastal areas after spring breakup of the ice.

A month later, a follow-up meeting was held between the two government groups, this time in Washington, and further refinements to cleanup and research guidance were promulgated and furnished the Air Force.

With SAC completing its search and recovery operations, further actions were directed by the Vice Chief of Staff. Air Force Logistics Command forces, under the Directorate of Special Weapons, planned and implemented their assigned task of removing all collected debris from Danish territory. The Aerospace Defense Command, as the operating command for Thule Air Base, provided security, radiological and crash scene monitoring, and performed a myriad of other support tasks required to meet agreement requirements between the United States and Denmark. Scientists and technicians from many Air Force units and other services assisted in accomplishing these tasks. All were directed, supported, and reported through the Broken Arrow Control Group acting as the agent for the Chief of Staff.

The list of individuals, offices, agencies, and departments who worked together as a team would fill the pages of a sizeable book. Countless unsung participants, many of whom performed in a prodigious manner with little or no recognition, can rightfully take pride in the fact that they rose to the occasion and met the challenge with professionalism.

SAC's dynamic forces were brought to bear and consequently have reaped the praise and respect of the free world for the professional and thorough manner in which they performed search and recovery operations.

The Aerospace Defense Command and its 4683rd Air Base Group took charge upon SAC's departure from Thule in March and served as a holding force, coordinating and supporting further cleanup, removal, and technical study operations. As host to many hundreds of people—technicians, scientists, foreign diplomats and the world's press—the Aerospace Defense Command presented a most creditable image of the Air Force to the world.

The Directorate of Special Weapons of the Air Force Logistics Command was tasked with the monumental job of safely removing all crash debris for disposition in the United States. The work was accomplished with dispatch and technical precision.

The Atomic Energy Commission's experts in the field of handling and disposing of radioactive waste materials closed out the episode when they completed the debris processing.

From the viewpoint of the Headquarters United States Air Force Broken Arrow Control Group, on which I was privileged to serve, it was clearly evident that the disaster preparedness plans of the Department of the Air Force and Government were dynamic, workable, and manageable. Valid and valuable lessons were learned.

Under the added pressure of international public interest, Project Crested Ice was a meticulous effort that severely tested the Air Force's ability to cope with a complex and costly situation.

In the final analysis the record will show—"Mission completed in an outstanding manner."

Mr Zinglersen briefing General Hunziker and staff.

Personnel of the Materiel Section in action.

EVALUATION OF POSSIBLE HAZARDS

THE DANISH THULE COMMITTEE

Considerations by the Danish authorities regarding the evaluation of possible hazards to the population in the Thule district and the precautions to be taken.

THE essence of the information received by the Danish authorities in Copenhagen after the B-52 airplane crash near Thule on 21 January 1968, was that an American military bomber carrying nuclear weapons had crashed on Danish territory. Reliable information concerning what had happened to the aircraft and to its cargo of nuclear weapons was not available at that time, but it was known that within a certain area near the site of the crash, small amounts of radioactivity had been detected.

In order to evaluate possible hazards to the population in the Thule district and the precautions to be taken, a close coordination was established between the National Health Service, the Atomic Energy Commission (both having certain administrative responsibilities for problems which might arise in connection with the use of atomic energy and radiation), and—of course—the Ministry for Greenland.

The initial considerations as to what the Danish authorities should do towards establishing and dealing with possible risks in connection with the accident, took place in the Ministry for Foreign Affairs on 22 and 23 January. During these discussions, the Ministry of Defense, in addition to the above mentioned authorities, was also represented.

As early as 22 January, in the course of these discussions, it was decided that a Danish Scientific Group should be sent to Thule immediately. As representatives of the Danish Government and in connection with operations initiated by the United States, this group was to establish and evaluate possible immediate and long-range effects of the accident on the local population and then take the necessary measures. The composition of the Danish Scientific Group, both during the first few days and after 29 January when the group was expanded with more Danish experts, as well as its objects and activities, are described in detail in the contribution by the leader of the Danish Scientific Group, Professor Dr Jørgen Koch, "Danish Scientific Group Investigations," and the following Danish contributions.

Before the departure of the group, which was delayed by 1 day because of landing difficulties in Thule, the Honorable Dr Carl Walske, Assistant to the U.S. Secretary of Defense (Atomic Energy), arrived in Copenhagen to brief the Danish authorities on the information available on the accident.

On 25 January, Dr Walske met with the team of Danish scientists and other officials from the Danish authorities involved, in order to pass on technical information on the accident which might be useful for the group's investigations in the Thule area. During this meeting, the first Danish-American discussions took place concerning the extent of and type of risks which might be connected with the spreading of radioactivity in the area. The discussions were based on the supposition that the plutonium contamination, which had been demonstrated, could have been the result of the explosion of the conventional high explosive surrounding the nuclear material in the unarmed bombs in one or more of the bombs during the crash, thereby producing the spread of fissionable material. At the same time, it was clear that nuclear reaction could not have been brought about by the crash.

The Danish Scientific Group left for Thule on the the afternoon of 25 January. During the time following their arrival, they carried out a series of investigations and operations in Thule parallel to and as a supplement to the American work. As will be evident, there was close coordination in the steps taken by the Danish and American authorities. On the basis of the information sent out from Thule, the Danish authorities in Copenhagen were able to continue to follow and evaluate developments accurately. Immediately after the crash preparations were started at Risø to enable Danish measuring operations to take place. As more information became available these preparations were expanded and intensified.

Some 2 weeks later, when the initial Danish investigations and measurements in Thule had been completed, and when the type and extent of the work which had been begun by the American group had been ascertained, nearly all of the Danish scientists returned to Copenhagen. Replacements were sent out, however, and during the following months there was always at least one Risø staff member in Thule.

Thus, when the Danish as well as the American initial investigations had been carried out at and around the crash area, meetings were set for 15 and 16 February to be held in Copenhagen between Danish officials and an American delegation under the leadership of Dr

Walske, together with a group of experts, both Danish and American, who had participated in the investigations in Thule. Previous to the Danish-American meetings, Danish officials and scientists had met to evaluate the investigations and evidence in connection with the accident, and to discuss measures required with regard to further investigations, clean-up of the area, etc.

At the meetings on 15 and 16 February, the information gathered by both sides was reviewed and discussed, both in meetings between all participants as well as in smaller working parties appointed to deal with particular aspects. Aside from an exchange of views and increased knowledge concerning the extent and nature of the accident, the meetings resulted in detailed agreements as to what measures should be undertaken with regard to cleaning up the area where plutonium contamination had occurred.

Agreements were also reached concerning further measurements and investigations on the land areas surrounding the crash site, as well as continued surveillance of possible ecological consequences. It was a basic premise for the agreements reached at the meeting that further talks should take place concerning modifications or extensions of the operations agreed upon if new information or evaluations should prove such operations desirable. Furthermore, it was also agreed that in the course of the continued work, close contact should be maintained between the parties. The joint press release of 16 February, issued after the meetings, follows:

"Scientists from Denmark and the United States have been meeting for the past 2 days for discussions of the technical questions arising from the B-52 crash at Thule, Greenland. The meetings continued the close cooperation which has existed since the time of the crash. Scientists of both nations have worked together at the scene of the crash and participated in the gathering of scientific evidence. The scientists reviewed the considerable progress which has been made at the site in collecting aircraft and weapons parts. Contaminated material will be removed from Greenland. They also assessed the extent to which radioactivity was released.

"It was agreed that under present conditions the radioactivity spread in the area is not a hazard to people or biological species, nor is any hazard foreseen for the future. Nevertheless, an effort will be made to remove the main part of the radioactivity which is on the ice. The conclusions of the scientists regarding the absence of hazards to the biosphere will continue to be examined in detail. Further supporting evidence will be accumulated through an extensive program of data gathering."

During the first phases of the Thule case, the organization and carrying out of the Danish investigations and operations as well as the coordination between the Danish authorities involved, had taken place to some extent in an improvised way. After the Danish-American meetings in February, it was agreed that as a continuation of the cooperation which had existed between the National Health Service, the Atomic Energy Commission, and the Ministry for Greenland, it would be useful to establish a restricted committee to maintain continued contact with the American authorities and to follow the execution of the measures and investigations which had been agreed upon. In close contact with government, this committee was furthermore to make additional agreements on any measures or investigations which might be deemed necessary for further clarification of any other factors connected with the accident, and take any additional measures for the protection of the population of Greenland against possible effects of the accident. On 8 March 1968, the Minister of Education (the Nuclear Installations Act which includes rules on the safety of such installations is administered under the Minister of Education), on behalf of the Government, approved the establishment of this committee. The following members were appointed:

H. H. Koch, Permanent Under-Secretary of State, and Chairman, Executive Committee, Danish Atomic Energy Commission.

E. Juel Henningsen, M.D., Deputy Director General, National Health Service.

Jørgen Koch, Professor, University of Copenhagen, and Consultant to the National Health Service.

H. Lassen, Head of Division, Ministry for Greenland.

Dr C. F. Jacobsen, Assistant Director, Risø.

H. L. Gjørup, M.Sc., Head of Health Physics Department, Risø.

Mr G. Vigh, Head of Section, Danish Atomic Energy Commission, was appointed as secretary of the Committee. The Committee maintained close contact with the Ministry of Foreign Affairs throughout.

Mr Vigh was appointed as secretary of the Committee. The Committee maintained close contact with the Ministry for Foreign Affairs throughout.

During the period following the meetings in Copenhagen on 15 and 16 February 1968, in accordance with the agreements reached, investigations and clean-up operations were carried out in the Thule area. However, on the basis of the negotiations between the American and Danish technicians and scientists working in Thule, and as a result of the contact between the American authorities in Washington and the above mentioned Danish Thule Committee, the measures taken were continuously adapted and in certain respects changed as further clarity of the circumstances of the accident was established.

As the above mentioned work progressed, it became evident that another meeting would be necessary for establishing a new overall evaluation of the case. What was needed was a comparison of the extensive Danish

Press people and team of Danish radiation experts are informed by U.S. General Hunziker, Feb. 27, in Thule, Greenland, about recovery attempts of radioactive bomb fragments from the B-52 bomber which crashed near Thule Air Base Sunday, Jan. 21. In front of the General photo shows from left: Engineer H. L. Gjørup, Hans Lassen from Ministry for Greenland, Professor O. M. Kofoed-Hansen, Professor Jørgen Koch and Master of Science Per Grande. Copyright:Nordfoto 29.1.68/OL Photo:LAD

and American measurements and investigation results, on the basis of which a revision and extension of the agreements reached in Copenhagen could be drawn up. For this purpose, a meeting was arranged in Washington for 18 and 19 March between the Danish and American authorities.

At the meetings, the progress of the work was discussed, including the nearly completed task of removing the contaminated snow from the crash area and the likewise nearly completed collection of airplane debris and fragments of the nuclear weapons. In addition, the scientific evidence collected by both countries confirmed that, as hitherto assumed, there were no risks involved for human beings, animal and plant life as a consequence of the crash. New agreements were reached as to the completion of the cleaning up of the area, the removal of aircraft debris and of contaminated snow and ice, as well as the completion during the coming summer of control measures, including a radioecological investigation program. The joint press release of 19 March follows:

"Danish and American scientists and officials met on Monday and Tuesday to review the status of operations at the site of the B-52 crash in January near Thule Air Base, Greenland. These meetings continued the cooperative approach to technical matters associated with the incident. Previous exchanges have taken place at Thule on a continuing basis and in meetings at Copenhagen.

"The participants discussed the program for removing contaminated snow. This had been jointly agreed earlier as a housekeeping measure, even in the absence of concern regarding biological hazards. Removal of contaminated snow is now nearly completed. This snow is presently contained safely in storage tanks and the contamination will be removed from Greenland.

"The group noted that removal of contaminated aircraft debris from the ice is nearly complete, except for small pieces which are still being recovered. The recovered aircraft debris is being stored safely in metal containers at Thule AB and will be sent to the U.S. for disposal.

"In addition to reviewing the housekeeping operations and agreeing that they are nearly complete, the scientists jointly examined the extensive data gathered from the ice at the crash point, as well as from outlying areas. These measurements have confirmed the earlier views that there is no risk for human beings, nor for marine, animal or plant life. Joint surveillance will, however, continue."

In the course of the spring and summer of 1968, the clean-up work of the area around the crash and the removal of the aircraft debris and contaminated snow

and ice were completed. The Danish health physicists from Risø followed the work (for further details, see article "Danish Health Pysicists' Activities", by O. Walmod et al.).

Already at the time of the February meetings in Copenhagen, the Danish authorities had emphasized that they wanted to ensure complete safety with regard to the risk of possible consequences for human beings and animal and plant life, also of possible long-run consequences. At the March meetings in Washington, this position resulted in agreements concerning the implementation of a Danish radio-ecological investigation program to be carried out during the latter part of the summer of 1968. The purpose of the investigation was to obtain further confirmation of the scientific evidence previously collected by both countries. A more detailed description of the program and its operation in August 1968 can be found in the article, "Ecological Survey" by F. Hermann and Christian Vibe. In support of the radio-ecological program, the United States furnished an oceanographic research submersible, the STAR III, for

The Danish Motor Ship, AGLANTHA.

the investigation of the sea bottom at the crash area. Reference is made to the following joint press release as of 9 August 1968:

"The Department of Defense and the Danish Atomic Energy Commission announced today the beginning of two wrap-up actions related to the B-52 crash last January in Thule, Greenland.

"First, Danish scientists will lead a joint two-part ecological survey. Second, approximately 600 containers of melted ice, snow and other residue, collected at the crash site, will be shipped to the United States for disposal.

"The joint Danish/United States ecological survey will begin at Thule in early August. It is part of a joint Danish/United States follow-up effort agreed upon at the last meeting of Danish and American scientists early this year. The survey party will again evaluate the environment in the crash area. Previous joint scientific findings established that there was no risk in the area for human beings, nor for marine, animal, or plant life as a result of the B-52 crash last January.

"This re-evaluation is in keeping with the conservative scientific approach followed throughout the recovery operation.

"The Danes will conduct the main phase on the surface where samples of plant and animal life will be collected and evaluated. Their party, operating from the 54-foot Danish motor ship, AGLANTHA, will consist of five Danish scientists, specializing in the fields of biology, ecology, hydrography, and health physics. One American scientist will also accompany this team. Their 1-month surface survey will also provide an opportunity to acquire new knowledge of the region's normal ecology.

"In support of the joint program, the United States is furnishing an oceanographic research submersible —the STAR III—which will survey the area below the crash site. Underwater survey operations are expected to be completed in August.

"In addition to the joint survey, the United States will remove previously collected ice, snow and aircraft debris from the Thule crash site. This low-level, radioactive residue will be sealed in containers and tanks and transported in three Military Sea Transportation Service (MSTS) ships during August and September to the United States for disposal.

"The ships will unload the material at the United States Army Port at Charleston, South Carolina. It will then be moved by rail for final burial at the Atomic Energy Commission (AEC) Savannah River plant near Aiken, South Carolina.

"As required, the shipment will be monitored during the entire operation to assure compliance with all existing safety regulations.

"Weapons debris was previously airlifted to the Atomic Energy Commission Pantex plant at Amarillo, Texas."

The material procured during the ecological investigation program was exposed to further radio-ecological investigations at Risø in the same way that previously collected material had been examined and measured.

The results of the radio-ecological investigations are described in the article by Asker Aarkrog. The investigations led to the following conclusions, as stated in this article:

The radio-ecological investigations have shown that the plutonium levels in the collected samples in no instances were such that they can be considered harmful to man or to higher animals in the Thule district or in any part of Greenland. Nevertheless the B-52 accident measurably raised the plutonium level in the marine environment as far out as approximately 20 kilometers from the point of impact. The highest concentrations were found in bottom sediment, bivalves and *Crustacea*. The higher animals such as birds, seals, and walrus showed plutonium levels hardly significantly different from the fallout background.

MAJ GEN R. O. HUNZIKER
SAC On-Scene Commander

THE COMMANDER'S POINT OF VIEW

WHETHER in war or in peace, adequate military response is based upon expecting the unexpected and being prepared to cope with any contingency. Aircraft are designed to fly; not to crash. Weapons are designed to destroy a target; not to have their parts spread over a peaceful countryside. Yet when these unplanned events occur, immediate action must be taken to determine the extent of the problem created, to contain and control the effects, and eventually to restore the affected area to a clean and safe condition.

This is the report of the search and recovery portion of one such effort, designated "Crested Ice," which was carried out under my command during the 70 days between the 21st of January and the 30th of March 1968. It is not a technical summary; there are specialists who can provide that. It is, rather, an overview of the problems faced, management decisions made, and the unique—at times unorthodox—approaches which had to be taken to meet contingencies as they arose.

The 21st was much like any other winter Sunday in Omaha—until about 3 o'clock in the afternoon. I had just finished lunch when I was alerted by the Strategic Air Command (SAC) Headquarters Command Post that a B-52 had crashed somewhere on the ice close to Thule Air Base at 4:39 p.m. Greenland time. The first reports were scanty, but enough to indicate that a recovery effort be initiated immediately. It was known only that one of our B-52s was down, and that it carried four atomic weapons which must be accounted for. Neither the cause of the crash, the fate of the crew, nor the exact location and condition of the aircraft and weapons wreckage had then been determined.

While such events are not planned, planning for them has taken place. I immediately called the command post and started the sequence of events which follows a "Broken Arrow," the code designation for an accident involving a nuclear weapon. The response was immediate and extensive. Specialists from a wide range of areas—disaster control,

radiation monitoring, explosive ordnance disposal, medical and others—were alerted, and followed the carefully prepared plans which it had been hoped would never have to be implemented. By 7:25 that same evening, my group and I were aboard a KC-135 headed for Thule. Among us was Col Chester Hockett who was invaluable as my chief of staff during the entire project. We arrived at 2:52 on the morning of the 22nd of January. My Disaster Control Team was met by Col Paul D. Copher, the Deputy Base Commander, and given a status briefing at the Base Service Club which had been converted into an office building for the team.

The initial response had been made by the Deputy Base Commander. He had informed the SAC Command Post of the loss, and had dispatched Mr Jens Zinglersen, a Danish National, to alert the Greenlanders to the danger and to warn them to stay away from the crash site. Mr Zinglersen, who had heard the explosion and seen the fire subsequent to the crash, volunteered to be of any assistance possible. During the coming days, he was an indispensable link with the Greenland population as he spoke both Danish and the native Greenland dialects.

After traveling to the village on the mainland to warn the Greenlanders in the locality, he and five other dog team drivers assisted in locating the aircrew survivors. At the time of my arrival, six crew members had been located, five within approximately 3 hours. The sixth, the only fatality, had been found a short time previously. The seventh and last crew member eventually was recovered some 20 hours after the crash.

The crash site was approximately 8 miles west of Thule on the open sea ice of North Star Bay between the mainland and Saunders Island. The aircraft had crashed on an almost due south heading. Initial helicopter reconnaissance reported only a blackened area approximately 300 x 2100 feet, with no large pieces of aircraft debris in sight except the engines. The weather was extremely cold — approximately -24°F. A 7-knot wind produced a chill factor which lowered this to the equivalent of a -53°F reading. January is the depth of the Polar darkness, which engulfs the northern region during part of every year. The sun would not be seen at all until the 14th of February, yet within 2 weeks of that time its glare would be so intense that sun glasses would be required to prevent discomfort and eye damage.

There were many unknowns . . . whether the aircraft had gone

Dogsleds with their Greenlander drivers.

Aerial photograph of the crash site.

through the ice, as appearances would suggest; whether the ice was strong enough to support the weight of recovery vehicles; where and what there was to recover were only a few of the many unanswered questions. Preliminary survey by some base personnel had indicated light alpha contamination. While this did not present an immediate danger, it necessitated full documentation of both amount and extent, and the development of immediate measures for its control and removal.

The first problem which had to be met was that of visiting the crash location. Since neither the thickness of the ice nor its ability to support vehicles were known, the first survey of the areas as well as much of the activity during the next several days was directly dependent upon dogsleds with their Greenlander drivers. Later, of course, more advanced methods of transportation were developed.

For one given to philosophical contemplation, the contrast between a sophisticated nuclear age and the basic survival methods of the Greenlanders gave pause for thought. It was ironic that one of man's most technically complex endeavors had gone astray and that recovery from its effects must depend upon the most primitive of methods. There was, however, little time for idle contemplation. There were pressing and serious problems which had to be met immediately and effectively. As was the case throughout the entire project, necessity and expediency dictated methodology.

Because of the possibility of contamination, the village where the drivers lived was monitored for radiation on the 25th of January and periodically thereafter. None was found except small amounts on clothing. Aside from the requirement temporarily imposed that they refrain from seal and walrus hunting in the area of the crash until permitted to do so again, the lives of these Greenlanders, except for those actively engaged in the recovery effort, remained unaffected.

Weather proved to be a merciless enemy during those early days. Storms repeatedly swept the area. Three days after the crash a surface wind of about 25 knots with gusts of 45 knots persisted for 12 hours. Three days later a comparable storm lasted for almost 24 hours. The equivalent temperature at times dropped below -100°F. The blowing wind, in addition to raising chill factors to an unbearable degree, created problems of visibility and aggravated the possibility of spreading the radiation in the loose, blowing surface snow. The extent, level and type of contamination had to be determined immediately if the problems inherent in the crash were to be kept under control.

These weather conditions also demonstrated the need for adequate shelters against the rigors of the storm. The Greenlanders, who served so long and well during the entire project, were pressed into building a small colony of igloos, capable of holding up to 100 people, which could be used in case of emergency. While these would serve well for survival, it was obvious they would not be adequate for an on-site base operations, which was essential. It was necessary, therefore, to develop an on-site camp from which operations could be directed. Early reports on the strength of the ice indicated that it was from 2- to 4-feet thick and in the process of thickening. This was heartening because it meant buildings could be constructed and roadways could be built to alleviate the transportation problem.

A few years ago in the missile development era, the term "concurrency" came into common use. Nowhere could it be more appropriately applied than to Project Crested Ice. It would have been desirable to construct the roads, then the camp, then engage in the search activities, and eventually to launch follow-up programs. Stark reality indicated the

Thule weather forecast.


Igloos built at crash site for emergency use during severe arctic storms.

infeasibility of this systematic approach. It was necessary to establish concurrently the on-site headquarters, determine the scope of the radiation problem, recover the weapon components and aircraft debris, protect personnel on the ice from hazards inherent in both the accident and in the environment, and begin procedures to control and reduce radiation hazards. In order to do all of these things simultaneously, a heterogeneous work force had to be mobilized and a firm and skilled guidance maintained to assure that concurrent actions were carried out rapidly and efficiently.

This mobilization involved personnel from Danish authorities and over 70 U.S. agencies, including elements of the Department of Defense, Atomic Energy Commission, State Department, and others—in all, over 700 people during the course of the operation. The maximum number of people in place at one time—565—was reached on 14 February. The sheer numbers of people and the fact that many had no experience in arctic operation presented difficult problems. They had to be outfitted with suitable clothing and equipment, briefed on the hazards of arctic operation, and watched to assure that required safety procedures were followed. Accommodations, transportation, and food had to be provided. The difficulties of integrating this diversified group into an efficient working force dictated a management decision which was important to the success of the operation.

It was decided at the start that available individuals would be used without regard for their normal chain of command. I resolved that this must be an organization of workers, not observers. Another pressing reason for deviation from normal chain-of-command procedures was that the time for solution of this grave situation was of undetermined but limited length. With the coming of warmer weather, the ice would break up and melt, and the crash site would disappear into the sea. Whatever was to be done had to be done before that time, and as rapidly as the unpredictable storms would permit. The available personnel, therefore, were divided into teams. Leaders were selected because of their experience and competence and regardless of current assignment or organization. Concurrent operations were conducted to the maximum extent possible.

Another major management decision had to be made within hours after my arrival. The teletype services of the world had flashed the news that a U.S. bomber had crashed on friendly territory. It was only natural that the world was interested in the import of the event and its possible ramifications. Because of its relative inaccessibility, it was difficult for newsmen to visit the scene. After consultation with Col A. J. Lynn, Chief of Information, Hq SAC, I decided that everything possible would be done to facilitate their transportation, provide accommodations, and assist in providing accurate information about the occurrence. "Credibility" was a watchword from the beginning to the end of the project. When information could be made available, it was given freely. Where security dictated secrecy, newsmen were so informed—frankly, without equivocation and without apology.

In all, 51 newsmen visited Thule. Twenty-five were from the United States and 26 from other countries, the greatest number from Denmark. At the press conference on the 25th, 10 countries were represented. I personally conducted four press conferences, one each day between the 25th and 28th of January. There were many questions, but those most frequently asked related to the extent of the explosion and the degree of the radiation hazard. In keeping with avowed policy, the press was informed without equivocation that there had been an explo-

General Hunziker with Jens Ziglersen and unidentified dogsled driver.

Camp Hunziker.

sion of the conventional materials in at least some of the nuclear weapons, that some radiation was present, and that there had been no nuclear yield.

Not only were there attempts to keep the world informed, but special emphasis was placed upon close coordination and cooperation with the local authorities, both military and civilian. It was considered essential that the local community be aware of the hazards presented and of the measures being taken for their control. On the 29th of January, a meeting was held with Mr Klaus Borneman, the Acting Governor of Greenland, and members of his party. This same close cooperation was maintained throughout the project.

The first step in the development of an on-site camp was the establishment of a heliport which, in addition to permitting quick access for search personnel, would permit supplies and materials to be flown in. Helicopters could not land on the ice because the rotor wash created a snow cloud which reduced visibility to zero. This problem was solved by airlifting sheets of plywood to serve as a heliport. When laid on the ice, the rotor also raised these in the air so that it was necessary to devise some method of fastening them down. This was solved by using water to freeze them to the ice surface. Once the heliport was functional, the arduous task of erecting the camp began. The local Danish workmen, who were responsible for the upkeep at Thule, assisted tremendously in this task. Prefabricated huts were built at the base, transferred to the crash site, and erected on the ice. The first such building was completed on the 24th of January—less than 2 days after the arrival of the Disaster Control Team. The second building was ready on the 25th. The completion of the buildings was only the first step toward a functioning facility. Generators for lighting, heaters, telephone, and teletype lines all had to be installed and maintained.

The use of ground vehicles was authorized following a survey of the ice which indicated that it could hold vehicular traffic as long as there was adequate spacing so that too much weight was not placed on any one segment. Two roads were built—one for incoming traffic, and one for its return. In order that one of these roads might "rest," a third road was also built so that only two were in operation at any one time. With the completion of the roads, the immediate logistic problem of the on-site camp (designated "Camp Hunziker" by Colonel Lynn) was essentially solved.

The problem of maintenance, however, had only begun. Because of the press of circumstances, it had originally been planned that the work of recovery and decontamination would be carried out on a 24-hour basis. It soon became apparent that this was not possible. The intense cold took its toll, not so much of men but of equipment. Flashlight batteries would last only 10 minutes. Equipment designed for use in milder climates broke with unpleasant regularity. Engines had to be kept running. If one stopped, it could not be started again. Batteries on the radiation monitoring equipment failed. An on-site fix greatly alleviated this particular problem: Batteries were carried inside the outer clothing while the monitoring instrument was held in the hand. Gasoline lanterns were ordered from the U.S., and eventually floodlighting was installed. The extensive maintenance problems, however, made it necessary to divert at least one shift out of each 24 hours to repair and maintenance if the primary task was to be accomplished.

By contrast, the breakdown of the men was minimal. In spite of the intense cold, darkness, bulky clothing, poor visibility, contamination, and generally austere working conditions, the men assigned to the task worked long hours without illness or accident. It is also noteworthy that there were no vehicular acci-

Equipment failure—road grader with broken-front axle.

In intense cold and darkness, workers searched the blackened area.

dents during the entire operation.

The first searchers in the area had observed the blackened crash site and the fact that alpha radiation from the dispersed plutonium from the weapons was present. In order to define the limits of radiation, monitoring of the area was done so that by the 25th of January a zero line was established. This comprised a rectangular area which was physically enclosed by ropes strung between reflectorized stakes. The term "zero line" signified the point at which radiation was at a zero reading.

Accurate determination of the levels of radiation depended upon radiological monitoring, utilizing grid methods to obtain readings at systematically defined points. Doing this was complicated, as were all other activities, by the low temperatures and instrument failures. Eventually the task was completed and a contour map indicating the areas of various concentrations could be developed. As had been anticipated, by far the greatest percent of all radioactive material was in the blackened area which resulted from the explosion and fuel fire that followed the impact. It was apparent that removal of the black snow crust from the top of the sea ice would result in elimination of essentially all the plutonium contamination.

From the start, decontamination procedures for personnel, equipment, and dogs had been in effect. Monitoring the first parties to visit the crash site showed contaminated clothing, particularly footwear. Nothing higher than a reading of zero was considered satisfactory for any except American personnel. For our own people, normal Department of Defense standards were accepted. At the on-site camp, a decontamination station was set up at the zero line. Personnel who had been at the crash site entered on the "hot" side, underwent gross decontamination, and exited on the "cool" side. Final decontamination was then completed at an on-base facility. In order to reduce the load on the decontamination personnel, every effort was made to restrict entrance into the contaminated areas. Vehicles from the Air Base not directly utilized in the search effort stayed outside the zero line.

Decontamination procedures were standard. Most of the contamination was removed by simply brushing the snow from garments and vehicles. Thorough cleansing eliminated most of the rest. In those few instances where contamination had impregnated the materials, the clothing was replaced. This latter decision accounts for the bill for three polar bear skins which became part of the expense of the recovery procedures. These skins were purchased to replace Greenlander pants which routine decontamination did not reduce to a zero reading. In addition to routine cleansing, nasal swabs were taken on all personnel and urine tests were taken if it was considered desirable. In keeping with the concept of using experience regardless of organization, CAPT R. E. McElwee, USN, of the Defense Atomic Support Agency, was given direct command of radiation control. The actual decontamination procedures were carried out primarily by members of the SAC Disaster Control Team.

Although a minimal direct health hazard, the radiation contamination presented an inconvenience to on-site search personnel as it was not possible for them to eat in the contaminated area. Because of the difficulty and time consumed in transportation, they were kept at the site for full 8-hour periods. Here, only liquids could be consumed. Soup, hot chocolate, and coffee were used by the gallon. Keeping these in a liquid state until they could be swallowed was not always a simple procedure. Not uncommonly, coffee froze in the cup if conversation was carried on too long. In order to accommodate these workers at the end of their shift, a dining hall on

Zero line.

Men taking a coffee break on the sea ice.

the base was maintained on a 24-hour basis.

A Weapons Division was established on 23 January with Col Robert S. Marcum as its chief. Its primary function was the recovery of weapon and aircraft parts. The initial search teams were instructed not to move any of the wreckage components. Understanding the dynamics of the occurrence could best be achieved if the parts in their relation to each other were clearly identified. This early survey located portions of all four of the nuclear weapons. The fact that all four had been accounted for was announced publicly on the 29th of January. The explosion which had occurred had completely disintegrated the aircraft. This relatively complete disintegration resulted in literally thousands of small pieces and accounted for the fact that early searchers found relatively few large aircraft parts. There was speculation at the time that portions of the aircraft might have plunged through the ice. There was, however, no practical method of evaluating this possibility, although later developments proved it to be correct.

It soon became apparent that while it was desirable, time would not permit the developing of an accurate wreckage grid. Because of the relative position of the north magnetic pole, compasses were nearly useless. It was almost impossible because of darkness and the lack of reference points to obtain an accurate heading which could be used to develop parallel grid lines. It was common for searchers who had been in the same areas and seen the same pieces of debris to vary widely in their descriptions of its location. It was decided, therefore, to pick up all pieces as they were located. This decision was further supported by high winds that scattered the small light weight aluminum parts, thus aggravating both the radiation and the recovery problems. Because of this, as the pieces were accumulated they were stacked into piles and covered with chicken wire until packaged for storage. In the final analysis, the search resorted not to scientific findings, but to use of mass manpower. It was conducted using airmen shoulder-to-shoulder systematically sweeping the area many times. The lines were maintained by noncommissioned officers (NCOs) whose primary function was to insure that the formations were kept intact. Although sensitive radiological and metal detecting equipment was available, the best mechanism for detection proved to be the human eye. Eventually, however, the weapons and aircraft parts on the surface were recovered and placed in barrels, cans, and drums. This phase was completed on the 20th of February. The nuclear weapons parts were returned to the U.S. and the aircraft wreckage stored for future disposition.

From the beginning, plans were made to support the operation with the best scientific talent available. The American scientific group was established on 25 January with the arrival from the Los Alamos Scientific Laboratory of Dr Wright Langham to serve as my Chief Scientific Consultant. Dr Langham is one of the world's leading authorities on the biological behavior of plutonium. With Dr Langham were Dr H. D. Bruner and Dr John Wolfe of the Atomic Energy Commission, and Dr Nathan Benedict and Dr Joseph Tinney of the Lawrence Radiation Laboratory. This scientific advisory group continued to grow until in all, 23 U.S. scientists were involved. They came and went as their duties dictated. The primary function of the group was to give me support on technical and scientific matters. A second and extremely important function was to serve as a liaison with the Danish scientific group, to work with them on a daily basis, and to assure mutual compatibility of goals and procedures. With the departure of Dr Langham on February 3rd, the control of this group

Workers picking up debris.

Aircraft debris piled up on the sea ice.

passed to Col Jack Fitzpatrick, Field Command Surgeon of the Defense Atomic Support Agency, who had arrived on the 31st of January.

The first group of Danish scientists also arrived on 25 January. This group consisted of Professor Jorgen Koch, an eminent physicist from the University of Copenhagen, and 11 select Danish specialists from a variety of fields. As soon after the arrival as possible, I met with the group, extended a welcome to them, and offered to assist in their survey in any way possible. They, in turn, expressed their desires for full cooperation and mutual assistance in the task at hand. After this initial briefing, the Danish members participated in the press conference with representatives of the Danish and U.S. press. The Danish team was given headquarters adjacent to command headquarters. Colonel Fitzpatrick, Dr Langham, and Dr Bruner were designated as the technical contacts for this group.

These scientific advisory groups were particularly useful in determining the radiation levels which ultimately resulted in systematic profiles of the entire area. In addition to surface radiological surveys and snow samples, it was apparent very early that many ice cores would have to be taken. This laborious task was begun on the 5th of February. The 3-inch cores were obtained by hand, drilling through the ice and by preserving the cores intact for subsequent photographic and radiological inch-by-inch monitoring. In all, over 180 cores were collated and processed in this fashion. Analysis of these cores revealed traces of tritium.

Systematic evaluation of the sea ice indicated an area approximately 100 meters in diameter which had been disrupted by the crash. In the central portion of this area, sea water and large blocks of ice had risen to the surface and been refrozen. Cores from this area were contaminated. Cores from other than the impact area were clean.

The Danish scientists were particularly interested in the long-term ecological effects which might be involved. In addition to routine radiation monitoring of the crash site, they were interested in obtaining samples of the sea bottom, the sea water, the snow, and the surrounding area. They were also concerned with the long-term effects on the flora, fauna, and human inhabitants in the area. Their ecological interests were influenced by the habits of the local and nomadic Greenlanders, with particular respect to food sources. They were interested in evaluation of wildlife, both surface and underwater. Although a firm decision had not been reached on the extent of these studies, it was anticipated that they would be continued and that the U.S. scientists would cooperate in every way possible. Obtaining sea bottom samples was a particularly arduous task. The same effort used to obtain ice core samples had to be expended in breaking an even larger hole in the ice through which grappling equipment with over 600 feet of attached line could be lowered.

On the 25th of January, the first information meeting was held in Copenhagen between Dr Walske, Assistant to the Secretary of Defense (Atomic Energy), and Mr Hans Koch of the Danish Atomic Energy Commission. At Thule, there were many informal meetings between the Danish and American scientists during the first few days on site. Two formal meetings were held on the 4th and 6th of February to consider problems of mutual interest. These concerned radiation monitoring, sample development of ecological studies, and discussions of the decisions which had to be made regarding the disposition of the wreckage and radioactive material. Another meeting was held in Washington on the 5th of February involving U.S. scientists and still another joint meeting in Copenhagen with Danish and American scientists and authorities on 15 and 16 February. It was

Barrels filled with aircraft debris, stored outside the zero line and awaiting movement to the base.

Road grader and men windrowing the contaminated snow and ice

mutually agreed that the radiation hazard was minimal and that if all of the radioactive material in all of the weapons was allowed to sink into the bay, the plutonium oxide would be diffused in the sea water and produce such diluted concentrations that no hazard would exist. It had originally been estimated that 1 cubic kilometer of water would be more than sufficient to dilute all of the plutonium oxide from all of the weapons to drinking water standards. Later calculations showed that only 1/500 of a cubic kilometer would have been required. In fact, North Star Bay contains approximately 50 cubic kilometers of water.

It was agreed that, while no serious radiation hazard existed, good housekeeping demanded that the area be cleaned up and the radioactive waste as well as metal debris be disposed of properly. This presented me with the second major series of problems to be faced in this operation.

It was first necessary to review manpower requirements and skills involved. It was readily apparent that the shift in emphasis required a shift in manpower and operations techniques. As this first phase was closed, large numbers of personnel were returned to the United States, and others, primarily those concerned with the civil engineering aspects of moving masses of material, were requested.

A number of proposals had been advanced as to how the contaminated snow and ice were to be collected. This was solved by scraping the ice surface and piling the material into windrows. "Hot" spots not scraped were monitored and removed by shoveling. The next major decision was how to store or dispose of the material. Suggestions for storage included the use of two-million-plus-gallon, above-ground storage tanks, the use of permanent underground storage tanks, the setting up of an on-site filtration plant, and, last, the use of a number of 25,000-gallon tanks that were at Thule Air Base. The last alternative was the one that was eventually selected. It was decided that the contaminated snow and ice would be placed in steel containers for storage pending final disposition.

The Danish Construction Company was engaged to assist in the preparation of the tanks. This was an excellent choice. The cheerful patience of this group of dedicated workmen, their hours of productive effort, and their willingness to serve, were major factors in solving the many problems yet to be faced. The tanks had to be removed from their installation, cleaned, and all openings welded shut. Holes were then cut in the tops of the tanks, through which the contaminated snow and ice could be dumped. The next problem involved removing the contaminated ice and snow from the crash site to the storage area. Plywood boxes 10-feet long were especially constructed for this purpose. The boxes were filled by continuous belt loaders and front-end loaders, and were transported to the base on flatbed trailers. On-base cranes lifted and dumped the contents of the boxes into the 25,000-gallon tanks. As the tanks were filled, the covers were welded back in place. In all, 67 tanks were filled with contaminated snow and aircraft debris, and an additional four tanks with general contaminated debris such as tires and lumber. Over 237,000 cubic feet of material were involved. Venting systems were installed to relieve any internal gas pressure which might develop when the snow and ice melted. Evaluations indicated that no problem of critical masses that could lead to a nuclear reaction was involved, so provision did not have to be made for this.

By the 15th of March the total area had been cleared. A radiation survey completed on that date and compared to one on the 27th of February indicated that the radiation hazard had been reduced to negligible proportions.

Men and machinery working on the sea ice.

Continuous belt loader filling boxes with contaminated snow and ice.

On the 18th and 19th of March, a U.S./Danish meeting was held in Washington to examine progress on the project. On the basis of the material presented, it was decided that the removal measures to date had adequately fulfilled expectations. At this meeting it was decided that the sun would be exploited to the maximum. To precipitate melting in the impact area, it was agreed that 25,000 square meters would be treated with black carbon sand. During the cleanup operations, it had been necessary to preserve good housekeeping habits since items thrown onto the snow produced faster melting, which in turn developed holes into which items as large as a trailer could be lost. It was anticipated that the heat absorbed by the black sand would act in the same way to accelerate melting. This would then accelerate the dilution of the residual radioactive material by permitting it to mix with the water in North Star Bay. Its initial use over a test area proved disappointing; however, with the longer summer days, melting was increased so the project was not pursued. It was also agreed at the meeting that the crash site would be fenced and posted. This project was completed on the 20th of March. By mutual concurrence, normal good health practices were to be followed in the decontamination of roads, vehicles, and loading areas. The Danish Atomic Energy Commission personnel also indicated that they would continue with their ecological studies.

In the final effort to assure that all aircraft and weapons had been collected, the area in and around the crash site was systematically ploughed and again inspected by long lines of airmen. Areas which were unsafe for such procedure were surveyed by use of helicopter, using radiation detection equipment suspended from a cable. In all, approximately 30 square miles were subjected to these treatments.

This work was completed at 6:00 p.m. on the 30th of March, at which time the evaluation and recovery portion of Crested Ice was officially terminated. Final storage, sealing and decontamination procedures continued until 10 April, when the last member of the Disaster Control Team departed Greenland. This was none too soon, for estimates had been given which indicated that approximately 1 May would be the last time that ice operations could have been continued safely.

Flatbed trailer loaded with boxes filled with contaminated ice and snow.

Crane at work on the sea ice.

Every experience, in retrospect, has highlights which make it memorable. No matter how grim, there are always pleasant interludes. One of these occurred in the Crested Ice Project when the American Ambassador to Denmark, Mrs Katharine E. White, visited Thule on the 24th and 25th of February. With her was the Honorable Erik Hesselbjerg, Permanent Undersecretary for the Danish Ministry for Greenland, and the Honorable Mr Hans Koch of the Danish Atomic Energy Commission, as well as other distinguished dignitaries. It was my pleasure to brief them and members of their entourage on the progress of the project to that time. It was also my pleasure to see Ambassador White present to Mr Zinglersen, the well-deserved USAF Exceptional Service Award for his outstanding contributions to the Crested Ice effort. This effort was a reflection of the full cooperation and tireless effort of all of the Danish and Greenlander personnel who became involved in the project.

Every project also has its amusing side. Because the Greenlanders were unable to hunt food for their dogs during the time that they were so ably assisting the early efforts of the Disaster Control Team, each dog had to be supplied 3.9 pounds of veal or horsemeat for each day it was worked. The Thule Commissary probably became the veal center of the Air Force and certainly the only one that stocked fresh horsemeat.

On the serious side, there were lessons learned that should improve

Air Force reaction to this kind of emergency. These lessons centered around good pre-planning, flexibility, adequate support, and priorities in handling requirements. There is always a conflict of interest between immediate accomplishment and appropriate documentation. The Crested Ice Project reemphasized the value of a carefully prepared program and adequate documentation to indicate progress as well as areas which required reconsideration. In the long run, comprehensive documentation is the keynote to the saving of time and money.

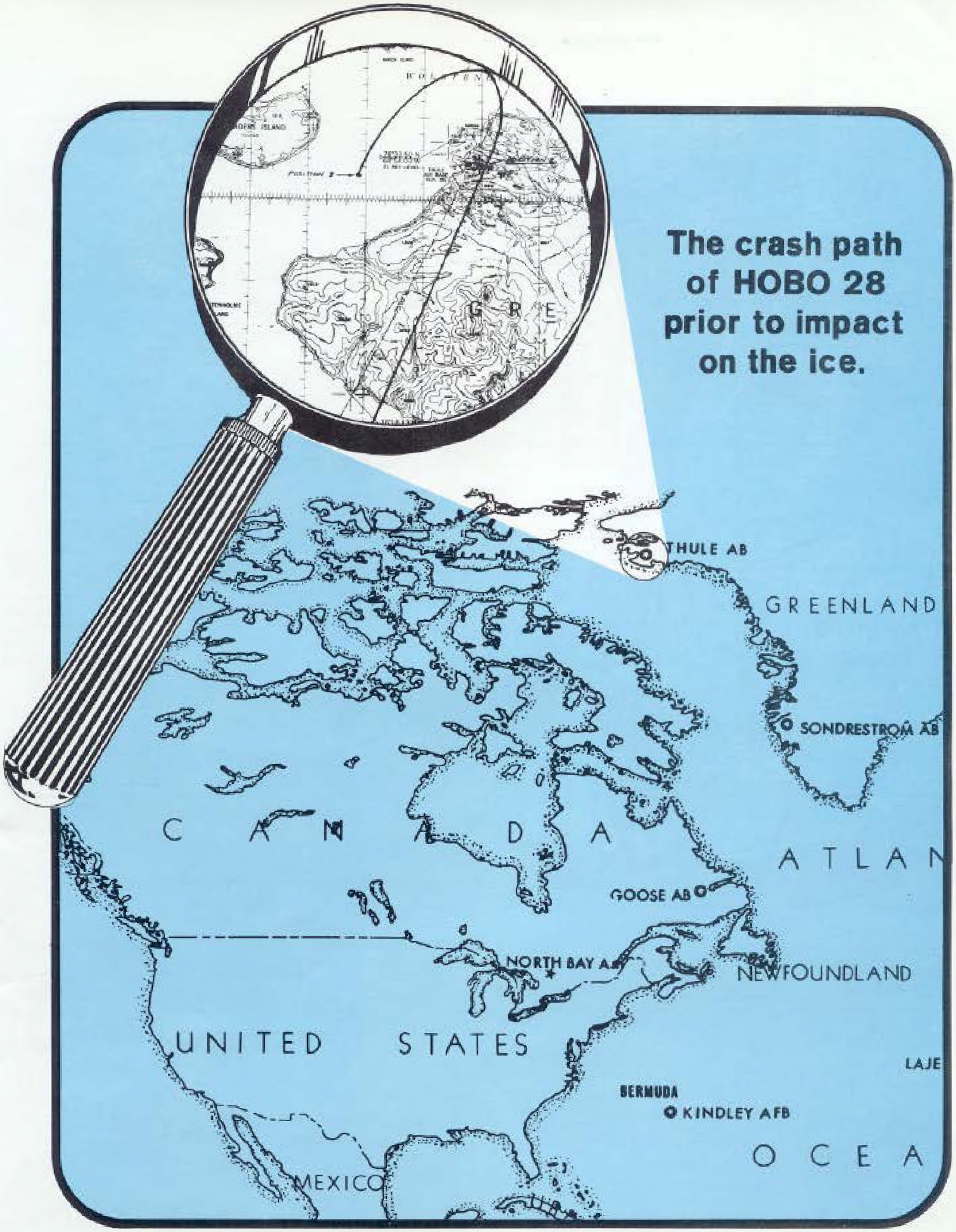
Loading aircraft debris into engine containers.

Workers scraping contaminated snow from the sea ice.

Crane lowering a chute onto 25,000-gallon tank preparatory to loading it with contaminated snow and ice.

Sealing a tank containing aircraft debris.

Hopefully, there will be no more Crested Ice or comparable problems. If, however, the project demonstrated any one thing, it was the almost limitless adaptability of well-trained, disciplined and motivated people. Their intelligence, ingenuity, and determination in solving a problem without precedent—in the most inhospitable of environments—was a source of great pride to me. To men like these, nothing is impossible. Their saga will be a continuing inspiration to all of us.


The crash path
of HOBO 28
prior to impact
on the ice.
THULE AB
GREENLAND
SONDRESTROM AB
CANADA
ATLAN
GOOSE AB
NORTH BAY AB
NEWFOUNDLAND
UNITED STATES
LAJE
BERMUDA
KINDLEY AFB
OCEA
MEXICO

HOST BASE SUPPORT

COL G. S. DRESSER
Commander
Thule AFB, Greenland

TO many people Friday the 13th signifies a day of ill omen. But to U.S. Air Force and Danish officials at Thule Air Base, Greenland, Friday, 13 September 1968 was a day of elation.

The last of 600 containers of low-level radioactive residue from Project Crested Ice were loaded aboard a U.S. Navy cargo ship for transport to the United States.

Air Force and Danish officials watched as a giant 150-ton crane hoisted the last 25,000-gallon container of debris, melted snow, and ice from the pier to the deck of the U.S. Navy Ship MARINE FIDDLER. Danish stevedores guided the tank to its resting place on deck and secured it with cables.

For the personnel at Thule this final act completed a difficult, painstaking task which had begun many months earlier when a B-52 bomber caught fire and plummeted to the frozen surface of Wholstenholme Fjord, 8 miles from Thule.

Except for the base air traffic controllers and a limited number of staff members, personnel at Thule were completely unaware of the drama taking place in the pitch-black sky overhead. The impact shattered the arctic stillness of that Sunday afternoon, rocking the base's concrete weighted buildings perched on pilings above the permafrost. Then someone spotted flames out on the bay ice toward Saunders Island. The Base Command Post flashed a message to Headquarters, United States Air Force, of an accident near the Aerospace Defense Command (ADC) installation at the top of the world. At one of Thule's mammoth black hangars, a stranger walked in and asked to use a telephone; he was Maj Alfred J. DeMario, a member of the bomber's crew. Major DeMario called the Command Post and reported to Col Paul D. Copher, acting base commander, that the bomber was carrying a crew of seven, at least six of them had ejected over the base area and that the huge stratofortress was carrying four unarmed nuclear weapons.

Within 10 minutes of Major DeMario's phone call, Capt John M. Haug, a pilot on the B-52, called in from another hangar. This confirmed Major DeMario's statement that the crew had ejected over the base. The Command Post dispatched an ambulance to pick up both men and take them to the dispensary where they were treated for bruises, abrasions, and chills.

The Command Post had been activated at 4:50 p.m. when it was notified of the plane crash, but until Major DeMario called no one had any idea if the crew had bailed out, where they had bailed out, or if they had gone down with the plane. Now the Command Post staff had a point of reference. All off-duty security police were recalled over the base-wide public address system and also over Radio 1425, Thule's Armed Forces radio and television affiliate station. Twenty-one security policemen split into seven teams and began searching the base and the roads leading to the various military sites in the hills above the main installation. All tenant units at sites in the 20-mile radius of the installation sent out patrols to search for the remaining members of the bomber's crew.

All personnel were instructed to report the sighting of strange lights or signals to the Base Command Post. It was imperative to find any survivor quickly. The temperature was a -23°F, the wind was blowing at 9 knots with a chill factor of 5. Exposed human flesh would freeze in 2 minutes.

Telephones in the Command Post were ringing constantly now. Someone reported sighting lights on South Mountain. More flashing lights were seen on the ice toward the wreck. Ground rescue personnel, driving trackmasters and two HH-43 helicopters assigned to Detachment 18, Eastern Air Rescue and Recovery Center, Military Airlift Command, investigated each report. Snow removal called to report that they had picked up another survivor near the base dump. He was SSgt Calvin Snapp, a gunner aboard the downed aircraft. An hour and 15 minutes had gone by since the plane crashed into the frozen bay.

Colonel Copher, on advice from Aerospace Defense Command Post at Ent Air Force Base, Colorado, dispatched four security policemen to the crash scene with ground rescue personnel. They were instructed

to stay 2,000 feet from the wreck. A helicopter hovered overhead at 1,900 feet and reported the impact had broken the ice. In spite of the heat of the burning wreckage the 3-foot thick ice had refrozen within minutes after the impact. The equivalent temperature was -50°.

Helicopter pilots (in Pedro II) spotted two parachutes and two ejection seats on the ice 3 miles out in the bay and began following the footprints leading away from them. A radiological monitoring team checked the shorelines from the base dump to the foot of Mount Dundas for radiation, but obtained negative readings. A security police team searching the southern slopes of South Mountain, 5 miles west of the base, found two more survivors walking toward the installation. Maj Frank F. Hopkins had a broken arm and Capt Richard E. Marx suffered from cuts and bruises. Pedro II evacuated the two to the dispensary.

By 9:00 p.m., aircraft from numerous Air Force bases in the United States were en route to Thule. A C-97 left Pease Air Force Base, New Hampshire, and a C-130 departed Sondrestrom Air Base, Greenland, with signal flares aboard. A C-130 also from Pease with two investigating teams aboard stopped at Goose Bay, Labrador, to pick up two pilots. An Explosive Ordnance Disposal Team and an information officer, dispatched by the ADC's Command Post at Ent Air Force Base, Colorado, were airborne. A Strategic Air Command Disaster Control Team under the command of Maj Gen R. O. Hunziker, Strategic Air Command Director of Materiel, took off from Offutt Air Force Base, Nebraska. During the next few days more than 700 military personnel, American and Danish scientists, and newsmen representing 72 different news media in North America and Europe would deplane at Thule.

At 1:30 p.m. Monday, 20 hours after the crash, searchers rescued the remaining survivor. Capt Curtis R. Criss was found wrapped in his parachute near South Mountain. Weak and suffering from a dislocated shoulder and severe frostbite, Captain Criss was evacuated by helicopter to the dispensary for treatment.

With the last crew member accounted for, the base's mission shifted to supporting the Strategic Air Command's recovery operation. All base personnel including the Danish Construction Corporation, the base's operations and maintenance contractor, began working 7 days a week along with the Strategic Air Command team to get the control and recovery effort started, and to support it as the tempo increased.

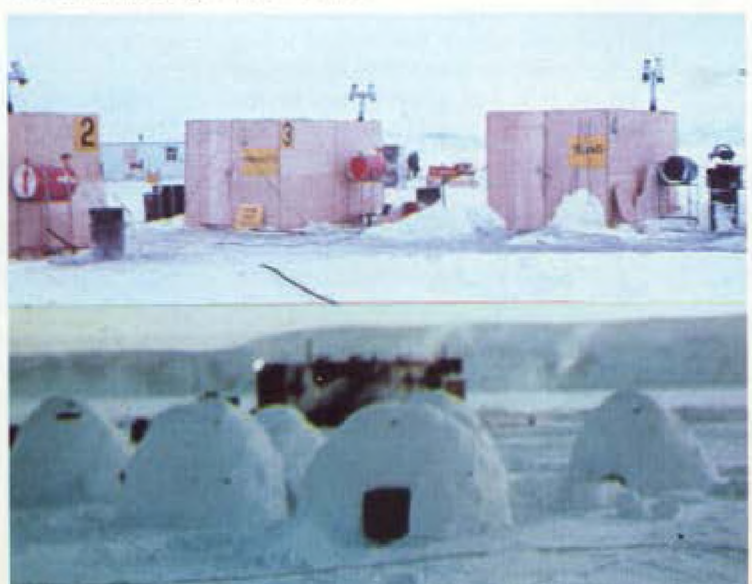
The first order of business was to establish a base camp at the site to provide shelter, equipment support, decontamination control points, and communications. The base shops built six small 8x16 foot buildings—they marked each piece as to location, then disassembled the buildings and packed the pieces for movement.

Within three days, the Prime Beef (Base Engineers Engineering Forces) Team, working in almost total darkness and bitter cold, had built a heliport and six prefabricated buildings; installed generators for electricity, telephone landlines and radio communications, and completed the first of three ice roads to the accident work area. Radiological monitoring teams had completely staked out the entire zero line with hundreds of reflectorized steel stakes made by the base shops. Floodlights were mounted on steel poles placed in weighted 55-gallon barrels to illuminate the area. Work crews now had an operating base for the recovery of aircraft debris.

Greenlanders built survival igloos as backup shelters in case a severe arctic storm should blow away the prefabricated buildings. Jens Zinglersen acted as guide, interpreter, and consultant to General Hunziker, the On-Scene Commander, and to Col C. S. Dresser, Base Commander.

Danes in the Packaging and Crating Branch of the Transportation Section constructed 14 sleds for use on the ice by the recovery teams. With sleds and tractors, the recovery teams began collecting wreckage. Using hand tools, sacks, marker poles and steel barrels, the men

Planting a reflector on the ice.



Prefabricated buildings and igloos—the beginnings of an operating base for the recovery of aircraft debris.

Recovery teams collecting wreckage—note the reflectors in the background.

Arctic building, 92- x 18-foot, on the sea ice.

walked shoulder-to-shoulder gathering bits and pieces of the aircraft ranging in size from a dime to a package of cigarettes. They piled the debris and secured it with wire net against the wind.

Road graders windrowed the snow in the area and personnel sprayed the windrows with foam to freeze them so that the winds would not spread the debris and contamination.

With the activities of the recovery operation increasing, there was a constant demand for more space at Camp Hunziker. A 92x18 foot arctic building was flown in and transported to the site in sections where civil engineers put it together. Civil engineers discovered three wannigans (portable buildings on skis) at Camp Tuto, an Army installation near Thule, and hauled them to the site. One was placed outside the zero line for decontamination control of personnel leaving the crash site; one was moved with the work crews to serve as a coffee break facility; and the other was placed midway between the shore and the site to be used as an emergency shelter. The men also erected a Jamesway building to serve as a supply point and built a second heliport.

Fourteen large R-4360 engine containers were flown in to be used to hold aircraft debris. Civil engineers found 11 large tanks in the base salvage yard and these too were used to contain wreckage. Danish construction workers prepared the tanks for use by sealing existing holes and cutting access openings. The tanks were then hauled to the site on large flatbed trailers, filled, returned, and welded shut. They were stored in the old Strategic Air Command munitions storage area. The cleanup of the aircraft debris was completed on 20 February.

During this period the various supporting base activities at Thule had performed their special functions. Security police controlled entry, exit, and traffic to the site; accounted for the numerous personnel on the ice and controlled the entry for the Disaster Response Force Command Post, and a holding area for classified material recovered at the crash site.

By 29 January, 65 security police from First Air Force had arrived fully equipped with arctic gear. After a 2-day familiarization briefing with local security police, the personnel manned the special posts

Road grader windrowing the snow in the crash area.

Danish construction worker cuts a filler pipe hole in the top of an R-4360 engine container.

Crane hoisting engine into container.

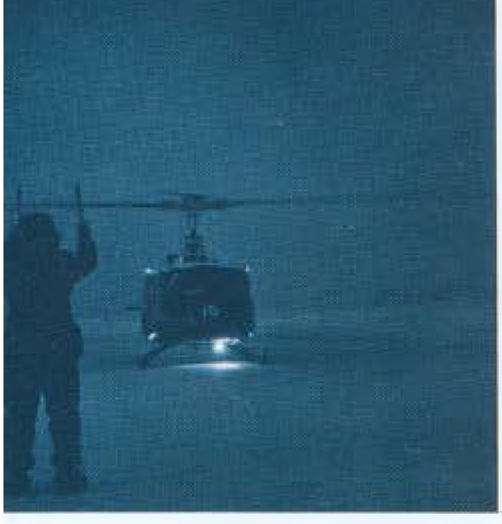
set up for the recovery operation.

One unique factor was that the supervision of security police forces was split. Base Central Security Control supervised security posts on base and in the debris storage area, while the On-Scene Commander directed security police activity at the crash scene. Both radio and longline communications were used to coordinate the activities of the two security forces.

Air Transportation Service coordinated, scheduled, and monitored all air traffic associated with Crested Ice. Due to Thule's isolated location and winter conditions, the only means of transportation was by airlift. Military Airlift Command and Strategic Air Command aircraft were used. Seventy-eight sorties were flown carrying 749 personnel and 1,770,499 pounds of cargo.

Air transportation was also the primary means of moving personnel and cargo from Thule to the crash scene during the first few days of the recovery operation. A task force of three HH-43s of Detachment 18, Eastern Air Rescue and Recovery Center stationed at Thule and three UF-1Fs of the 341st Strategic Missile Wing flown in on a C-133 from Malmstrom Air Force Base, Montana, were used. The choppers flew 1,583 sorties, transporting 4,524 personnel and 185,128 pounds of cargo.

Helicopter used in ferrying personnel to and from the camp site and Thule AB.



The Base Transportation Branch manifested all personnel and equipment going to the site at Hangar 6. Vehicle drivers presented a copy of the manifest, a modified entry and exit roster, to the guard at the entry control point at DeLong Pier. A person's name on the manifest was his authorization to proceed to the accident area. Transportation personnel forwarded copies of all manifests to the decontamination station in Building 773. As personnel returned from the site and were processed through decontamination, their names were crossed off the list. Personnel traveling to the site by helicopter were authorized to proceed to the site directly from Hangar 6. Upon their return, they were sent by bus to the decontamination center where their return was recorded.

Danish civilians employed by the Danish Construction Company controlled, dispatched, and maintained most of the surface vehicles. Three general purpose vehicles were made available to the team on a 24-hour basis for the On-Scene Commander, the ice survey team, and the supply services section. Other transportation requirements were superimposed on the normal base needs. Taxi runs increased from thirty thousand to seventy thousand a month. Vehicles were often used for tasks which they were not designed, and it was frequently necessary to attempt to match cargo loads to the vehicles available. When buses and other vehicles arrived from the United States, Transportation scheduled regular passenger and resupply runs to the site.

Base Supply coordinated requirements of the Weapon Recovery Division, Communications Division, Radiological Health and Contamination Control Division, and the Base Support Division for Project Crested Ice.

Three supply locations were manned 24 hours, 7 days a week, to respond immediately to all supply requirements. Daily, supply personnel monitored all outstanding due-ins and receipts to insure that received property was made immediately available to the requester.

According to a Strategic Air Command-Aerospace Defense Command agreement, Thule went directly to depots for stock numbered items using their transceiver or telephone. For local purchase items, base supply called the requirements to the Strategic Air Command where they were passed to the procurement office at Westover Air Force Base, Massachusetts. Aerospace Defense Command furnished the necessary funds to Westover for the procurement. Requirements for support of Strategic Air Command assigned aircraft passed directly from Thule to 8th Air Force Not Operationally Ready-Supply Control at Westover for lateral support and completed supply action.

Supply personnel processed many thousands of line items ranging from long underwear to weasel tractors. They maintained a complete status of equipment and items

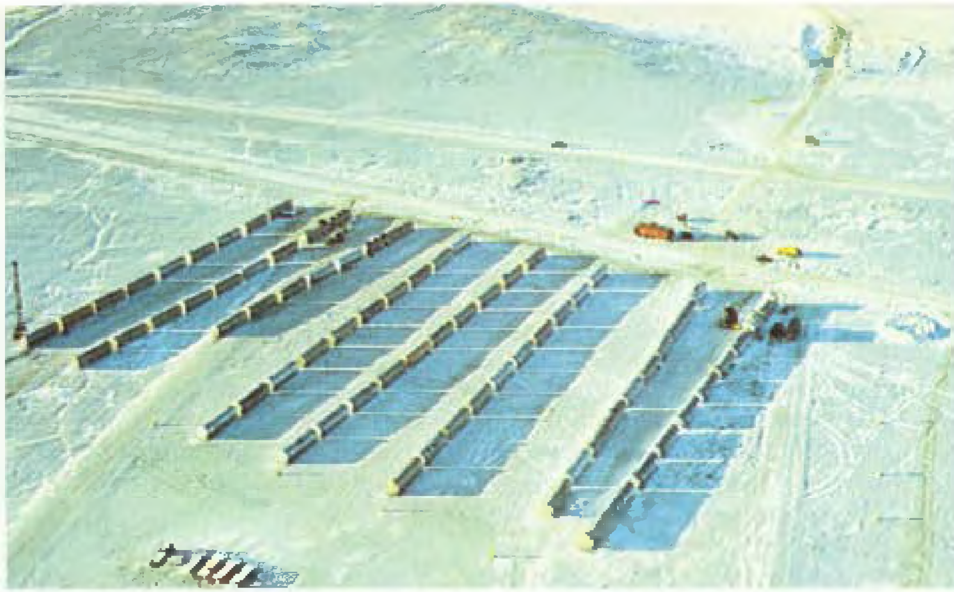
shipped including stock number, quantity, description, source and document number. All items were issued to the Strategic Air Command on custody receipt.

With the removal of the aircraft debris from the area completed, the Strategic Air Command Disaster Response Force departed and a new phase of operation began. The Danish-American meeting held in Copenhagen on 15 and 16 February had established the general conditions for the decontamination of the accident area. Tons of snow and ice contaminated at low-level would have to be removed. An expanded civil engineering division was established 1 March with full responsibility for directing the snow removal operation.

Under the direction of Lt Col Thomas W. Evans, Base Civil Engineer, and the San Antonio Air Materiel Area team chief, Danish construction workers disconnected abandoned 25,000-gallon POL tanks and transported them on flatbed trailers to Hangar 2 where workers steamed the tanks clean of petroleum and other possible explosive material. They welded all unwanted openings and cut three 5x8 foot openings for snow-loading in each tank. Workers moved the adapted tanks to a storage area near the shore for filling.

At the site, Air Force personnel, driving road graders, windrowed the black crusted snow, and mechanized loaders poured it into 10-foot long, 7-foot wide, 4-foot deep wooden boxes placed on 30-foot flatbed trailers. When the boxes were full, military personnel at the site placed tarpaulins over the tops to keep the snow from blowing. The flatbed, covered with a double layer of plywood to facilitate decontamination, was swept clean inside the zero line and hauled to the site control point where another tractor pulled it to the tank storage area.

At the storage area, Danish crane operators lifted the boxes in slings and tripped the hinge on the end of



Aerial view of tank form showing converted fuel tanks being loaded with ice.

Mechanized loaders filling wooden boxes with black crusted snow.

Tarpaulins being placed over the tops of boxes to keep the snow from blowing.

the box to let the snow tumble through a specially constructed metal chute into the tank. When the tanks were full they were sealed and fitted with a pressure vent. A total of sixty-seven 25,000 gallon tanks were filled with low-level radioactive residue. An additional four tanks were filled with contaminated equipment such as brooms, tires, and handtools.

After the area was clean of contaminated snow, civil engineers spread the cracked ice section (impact point) with black carbonized sand to absorb the sunlight and melt at a faster rate than the ice around it.

Workers painted the tanks black to absorb the sun's energy in order to melt the snow and ice inside. The San Antonio Air Materiel Area shipped specially constructed plastic greenhouses to Thule to speed the process. These proved effective until the first arctic storm blew them out to sea. As it turned out, the black paint did the trick. The resulting water was pumped into smaller containers to facilitate shipping the residue and the lightened 25,000-gallon tanks to the United States for disposal.

During August, Danish and American scientists, using a 54-foot Danish motor launch, MS AGLANTHA, and a 24-foot minisubmarine, STARR III, conducted repeated radiological surveys and ecological studies along the shores of Wholstenholme Fjord to insure that no contamination remained in the area.

The U.S. Navy Ship MARINE FIDDLER sailed with the last container of contaminated residue Tuesday, 17 September 1968, on an 11-day voyage to Charleston, South Carolina, where the containers and their contents were moved by rail to the Atomic Energy Commission's Savannah River Plant near Aiken, South Carolina.

As the huge cargo ship picked its way through the icebergs in North Star Bay and began slipping into fog-shrouded Wolstenholme Fjord, bystanders on the pier smiled as they read an inscription someone had painted on the end of the last barrel: "That's All Folks!"

Snow being poured through a specially constructed metal chute into 25,000-gallon tank.

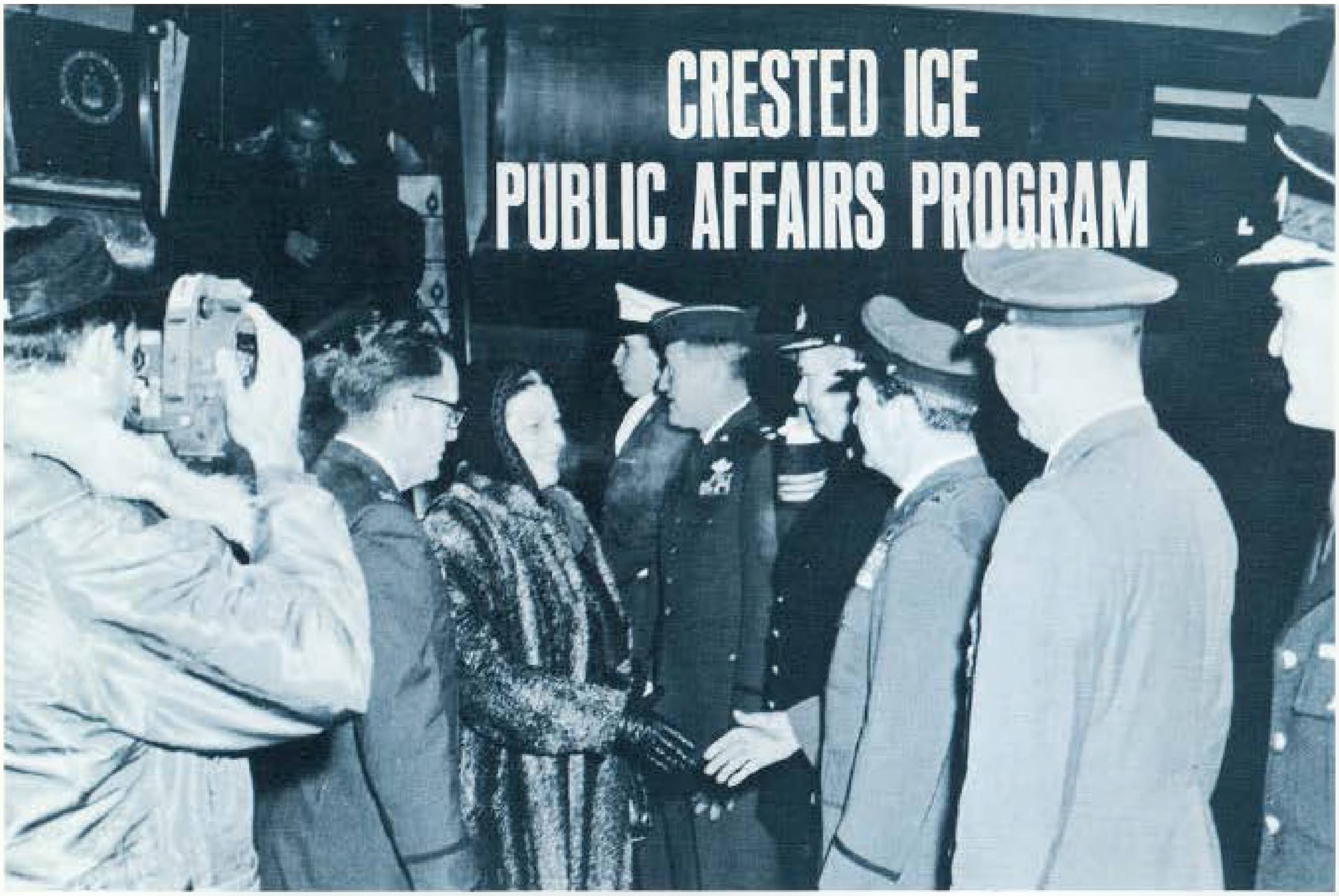
Landing gear being prepared for removal from the sea ice.

The Air Force tugboat at Thule AB eases the U. S. Navy Ship MARINE FIDDLER out into foggy North Star Bay.

Unloading mini-submarine, STAR III, onto flatbed at Thule AB.

Col C. S. Dresser, (right), base commander at Thule AB, and Commander Jorgen Molgard, Danish Liaison Officer, make a clean sweep of Project Crested Ice.

CRESTED ICE PUBLIC AFFAIRS PROGRAM



DIRECTORATE OF INFORMATION
HQ, Strategic Air Command

MEMBERS of the Strategic Air Command Directorate of Information (DXI) are well aware that each aircraft accident is different. Each involves variable circumstances which often present unique problems in making complete and factual information available to news media as rapidly as possible.

Thus, when SAC DXI was alerted by the command post shortly before 3 p.m. (CST) Sunday, 21 January 1968, that a SAC B-52 Stratofortress was down near Thule Air Base, Greenland, reactions were prompt and based on well-established procedures.

THE ALERT

The first call was to the Public Information Division's Disaster Control Team (DCT) alert officer. He is always on telephone alert and is prepared to deploy immediately with the SAC DCT to the scene of any SAC accident having a major effect on a civilian community.

Within minutes the DXI office was staffed by the Director of Information, Col Mason A. Dula, his deputy, Col Alfred J. Lynn, and representatives from the Public Information Division. In addition to the sketchy initial notification of the accident, it was learned that the B-52, with nuclear weapons aboard, was from the 380th Strategic Aerospace Wing, Plattsburgh Air Force Base, New York.

While the DCT staff was forming, the Secretary of the Air Force Office of Information (SAFOI) alert officer was notified. The Director of Information also contacted Phil Goulding, Assistant Secretary of Defense for Public Affairs (ASDPA), and Maj Gen William C. Garland of SAFOI. It was then agreed that SAC DXI would draft the initial news release and coordinate it with Mr Goulding's office for release. (As the only specified command in the Department of Defense, SAC works directly with the Office of the Secretary of Defense on many matters, particularly those involving public affairs.)

As a member of the DCT, Robert J. Boyd, a civilian historian, arrived at Thule on one of the early deployments. He was able to gather material and begin the documentation of events—as they occurred—rather than retracing past events.

By being on the scene during the critical first two weeks, the historian established his requirements for the staff, and built a foundation for his final report. As the search and recovery operation continued, the DXI staff was able to gather source documents and compile reports necessary for an accurate story.

It should be noted that the final report of the Palomares accident was on file with the Historical Division. It was taken to Thule and used as an organization guide.

THULE

The first news release concerning the accident was drafted by SAC and coordinated through the Defense and State Departments and also with the Government of Denmark. It was released by ASDPA at 9:45 a.m. (EST) 22 January.

The first announcement acknowledged that the crash had taken place, identified the aircraft's home station and unit, and stated the aircraft was carrying nuclear weapons which were unarmed so that there was no danger of a nuclear explosion at the crash site.

The announcement confirmed some of the rumors which had been circulating among a few news medium representatives in the Plattsburgh Air Force Base vicinity. The release naturally provoked a deluge of inquiries directed toward ASDPA, SAC, Thule Air Base, and Plattsburgh Air Force Base.

Weather and travel conditions from Thule to the accident scene, approximately 8 miles out on North Star Bay, prevented immediate response to most questions.

RELEASE RESPONSIBILITY

The responsibility for release of information for the United States rested with ASDPA, represented by Col Willis L. Helmantoler who arrived at Thule in a matter of hours after the SAC DCT. He remained for the next 7 days. Colonel Helmantoler and the SAC officers worked jointly on the early release of information on the Thule accident to the news media. After Colonel Helmantoler's departure, however, United States release responsibility rested with the SAC Information Officers on the scene who acted on behalf of ASDPA, USAF, and SAC.

On 1 February, ASDPA delegated the authority to the SAC Directorate of Information to release daily public affairs summaries, and later added the authority to periodically release photographs. Forty-one consecutive daily summaries were provided 14 addressees for reply to news queries. Once Project Crested Ice operations settled into a routine, the daily summaries were discontinued. Periodic reports were provided whenever new information warranted them.

There were three U.S. points of information release: ASDPA in Washington, SAC DXI at Thule, and the American Embassy in Copenhagen. The latter, however, generally deferred to the other two agencies in matters of technical expert opinion and facts. Particular care was taken to keep the Danish Government informed on all announcements. All other policies followed were general public information policies spelled out in Air Force Regulations 190-10, "Release of Information on Accidents," and 190-12, "Release of Information to the Public."

A second news release was made by ASDPA approximately 7 hours after the first. It described the aircraft's approach for an emergency landing after declaring an emergency because of fire in the navigator's compartment and intense smoke in the cockpit. It concluded by describing the locale and the extremely difficult environmental conditions under which searchers were operating. Because of these difficult search conditions the acquisition of new information was very slow. Thule temperatures were below -25 F. The area was in polar darkness except for a 2-hour twilight period each day, thereby requiring flares to assist searchers in helicopters and dogsleds. This second news release noted that more details would be available as additional dogsled teams returned.

The third news release was made at 2 a.m. (EST), 23 January. It summarized a 2-hour visit made by a ground survey team by dogsled to the scene. This release described the fuel-burn pattern on the ice and the small fragments in and around the burn area. More important, the announcement stated that none of the parts located were identified as nuclear weapons or parts of them. Also, a nonhazardous amount of "light—fixed and closely confined" radioactivity was found in the survey area. In an effort to report all available information, this third release went on to point out that personnel on the scene had picked up limited amounts of low-level radioactivity on their footgear. All were reported to have undergone normal decontamination procedures with no resulting problems.

FIRST DAYS

During the first 3 days when these news releases were made, news media interest in the crash was intense in the United States and Europe—particularly Denmark. The initial public announcements generated a variety of questions. Some could be answered readily; most required research or coordination with Thule DXI who worked out replies with Danish, Greenland, and American scientists at the scene. Other questions touched on classified information and simply could not be answered.

Despite the fact Thule was geographically difficult to visit, newsmen indicated considerable interest in traveling to the accident scene. The difficulties in getting there, however, did discourage a number of them.

Two press visits materialized early. Members of the press arrived at Thule within an hour of each other, about noon on 25 January. The first group included 25 American newsmen flown in by ASDPA. The second group of 26 newsmen included Danish, French, West German, and British reporters who arrived on a Scandinavian Airlines System flight after coordinating the visit with Danish officials and the American Embassy in Copenhagen.

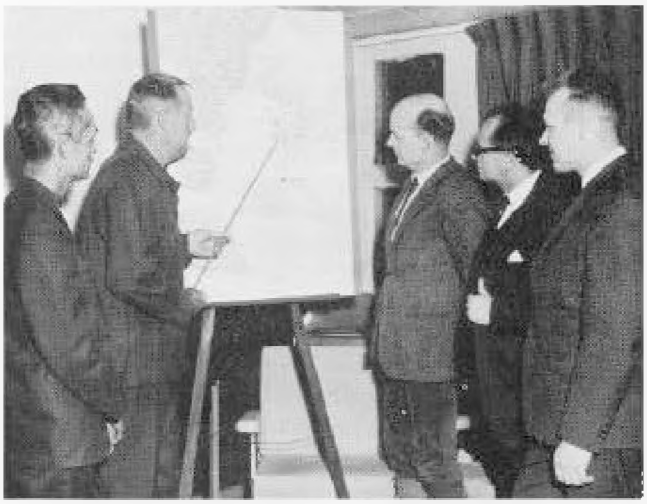
PRESS PROBLEMS

The arctic darkness and severe weather caused some problems in accommodating the 51 newsmen. Transportation of the newsmen to the accident scene was difficult and time-consuming. Two flights were made over the crash area in an Air Force C-121. Photographers and newsmen were airlifted to the scene by helicopter.

Darkness, extreme cold, and bulky arctic clothing made identification of newsmen at the crash scene and

the base a problem. Small DOD press badges were not adequate; therefore, armbands labeled "Press" were locally produced, easing the problem.

Photographs taken during the first few weeks following the accident were poor. The polar darkness and cold provided serious problems. Shutters became inoperative and batteries failed after only a few minutes exposure to the numbing cold. It was cumbersome to use many cameras due to bulky clothing. Rubber flash attachment extension cords became so brittle they disintegrated in the cold.



Maj Gen Richard O. Hunziker (2nd from left), SAC On-Scene Commander, and Dr Wright Langham (left) of the University of California's Los Alamos Scientific Laboratory, briefing Greenland officials shortly after their arrival at Thule AB.

PRESS CONFERENCES

Four press conferences were held during the early days when the first large group of newsmen were at Thule. Maj Gen Richard O. Hunziker, DCT commander, hosted four conferences which included participation by members of Danish and American scientific groups at Thule. The third conference in the series consisted of a short interview with the B-52's aircraft commander, one of the survivors still at Thule.

General Hunziker informed the press that there had been an explosion of the conventional materials in at least some of the nuclear weapons, that some radiation was present, and that there had been no nuclear yield. Credibility in the conferences was strengthened by the openess with which everyone answered questions and the maximum Danish and American scientific participation.

Because of the extreme sensitivity of all public affairs actions concerning the crash and recovery proceedings, the release of all information was triple-checked to make certain it did not mislead or distort, and that it was in the best interest of the nations concerned. Such a challenge was never-ending, for it required utmost integrity and perception to distill the often technical, often classified facts into a releasable piece of information comprehensible to the general public. The fact that information of this nature could be exchanged during detailed press conferences attests to the briefers' overall knowledge of the situation. They received full support from the DCT staff and scientific groups in preparing for the conferences.

COMMUNICATIONS

Virtually nonexistent commercial telephone and wire service to outside points caused some communication problems for newsmen. Arrangements had been made for copy to be filed through Dundas Radio, a Greenland village station about 8 miles from Thule. Although a system had been established for hourly delivery of news copy, this proved untimely and awkward for the newsmen who wanted to file each story immediately as material became available.

One military telephone line to Cornerbrook, Canada, was made available. Calls out of Cornerbrook were placed collect to the United States or Europe. Those to Europe experienced some difficulty getting through since overseas calls had to be billed to a U.S. address, but generally the system worked well. Calls were normally limited to 5 minutes and priorities were established by newsmen drawing numbers from a hat. Photographs were sent at the conclusion of each daily session.

All of the American newsmen, except four, returned to the United States with their ASDPA escorts on January 27th. Thereafter, formal news releases were made almost daily. Many replies to queries were researched and answers provided. The newsmen remaining at Thule were handed a short statement on January the 29th which announced that parts of all four nuclear weapons had been found. The release stated that serial numbers on fragments found on the ice at the crash site corresponded with SAC records of numbers on various components of the four weapons. The three-sentence announcement concluded by saying that the search was continuing for the remaining weapons fragments. The last of the 51 newsmen left Thule on 31 January.

During the next 2 months only three more news media visits were made to Thule.

PROTOCOL

Although considerable time was required to escort the visiting newsmen, the DCT information representatives were also involved in protocol matters and liaison with scientific teams. Normally information personnel prefer to point out that events involving protocol also invariably have news media interest, and that the information man best be left to meet the needs of the press. However, events at Thule demanded the attention of a senior officer knowledgeable in all facets and ramifications of the operation, one capable of acting as an

intermediary between the military, scientific, and governmental agencies of the countries involved. Colonel Lynn, by virtue of his years of information experience and his close working relationship with General Hunziker, was ideally suited for this responsibility.

Since the Government of Denmark obviously had an inherent interest in all Project Crested Ice actions, Danish and Greenlander officials and scientists had to be kept fully apprised of all actions taken with respect to the search, debris recovery, decontamination, and long-range clean-up planning. Similarly, American scientists and State Department officials had an equal requirement and interest. News releases and answers to media questions had to be discussed and coordinated with these individuals. The rapport established with these individuals and groups during the crucial early stages of operations extended to liaison on matters in many other areas and proved beneficial to the overall success of the public affairs program.

THE DXI TEAM

Unlike other Disaster Control Team members who remained at Thule throughout Project Crested Ice, the two SAC Directorate of Information representatives and Combat Documentation Team members were rotated every several weeks. While Colonel Lynn primarily directed public affairs throughout the first 5 weeks, other select officers and noncommissioned officers participated without in any way diminishing the daily effectiveness of the information program. The rotation provided a training experience that could never be "simulated." The experience gained by those involved fully justified the rotations.

Mr Jens Zinglersen, a Danish citizen who was the Thule area representative of the Royal Greenland Trade Department, Ministry for Greenland, provided invaluable services throughout the operation. The importance of his technical assistance and untiring efforts at the accident scene during the first days were obvious to all who depended upon him. It was therefore gratifying that the United States Government officially acknowledged Mr Zinglersen's valued contributions by awarding him the Air Force Exceptional Service Award. The presentation was made by the U.S. Ambassador to Denmark, The Honorable Katharine E. White, in a specially arranged ceremony on 24 February 1968.

The DCT information personnel were responsible for making arrangements for the visit of Ambassador White and her party, which included distinguished Danish officials and five Danish news media representatives.

After Ambassador White presented the award to Mr Zinglersen the entire visiting party toured the accident scene and held a press conference.

IN RETROSPECT

If one were to attempt to pinpoint a single reason for the success of Project Crested Ice's public affairs program, he would undoubtedly have to hedge a bit and attribute it generally to cooperation. True, full disclosure about the presence of weapons and the search for them was made rapidly, and daily follow-up reports about the status of operations at Thule contributed immeasurably to a lessening of public concern.

None of this information could have been made available as quickly, fully, and as frequently as it was without the unqualified cooperation and coordination of the United States and Danish Government officials, scientific team members, and the many agencies involved with Project Crested Ice.

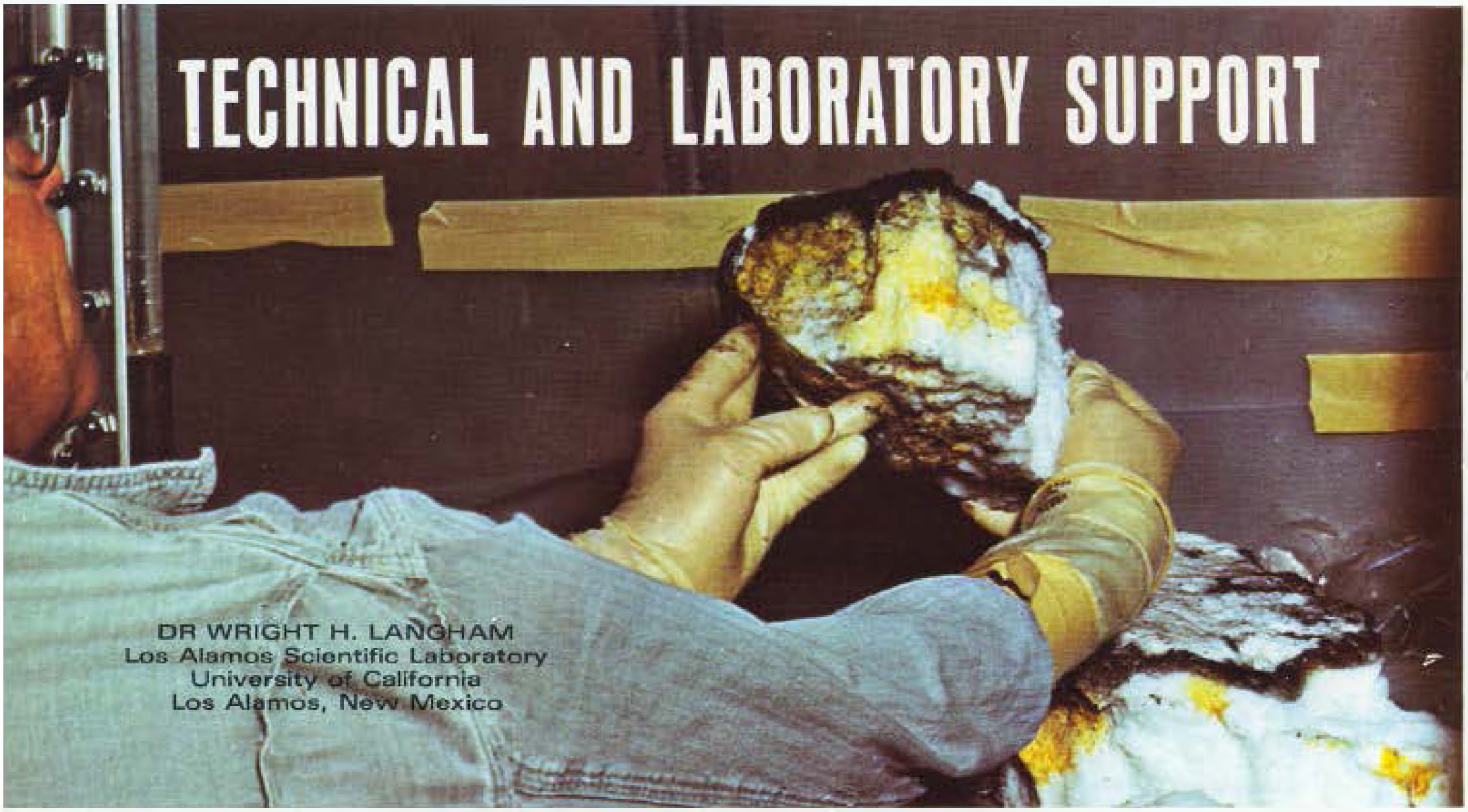
Such cooperation permitted spokesmen for both countries to discuss the accident and subsequent proceedings candidly and fully with newsmen, thereby discouraging uninformed speculation and any resultant unnecessary fear.

When the last 25,000-gallon tank of melted snow from the accident site was loaded at Thule for shipment to the United States, the most significant thing about the event was that it was Friday, the 13th of September 1968. There was no ceremony, no need to call attention to the climax of a gigantic task, and no requirement to reassure everyone that all was well. This confidence had been established and accepted long before.

Instead of any fanfare, some unknown soul merely annotated the final tank: "That's all folks!"—and it was.

Ambassador White presenting Mr Zinglersen with the U. S. Air Force Exceptional Service Award.

General Hunziker talking with Ambassador White's party on the sea ice.



TECHNICAL AND LABORATORY SUPPORT

DR WRIGHT H. LANGHAM
Los Alamos Scientific Laboratory
University of California
Los Alamos, New Mexico

A contamination incident such as the one described in other articles in this magazine invariably creates a real or anticipated need for specific technical information not readily available or easily obtained under field conditions. The type of supplemental information required is usually determined by the specific needs of the field commander and various special committees and policy-setting groups as an adjunct to their making decisions as to the extent of contamination, the magnitude and nature of the potential hazards to operational personnel and the inhabitants of the region (whether direct or through ecological modes), and the extent of decontamination that is acceptable and technically feasible.

Within 5 days after the incident an American technical advisory group was assembling at Thule, and discussions were initiated with a similar group of Danish and Greenland scientists. In the next few weeks various agencies (Atomic Energy Commission [AEC], Department of Defense [DOD], etc.) assembled expert committees to advise them. In addition, joint U.S.-Danish policy-setting groups met in Copenhagen and Washington to consider the technical aspects of the incident. The final decisions as to clean-up levels, methods of disposal and many other issues were made by these high-level groups and committees. Since these authoritative committees and groups needed all the information possible within the time frame of the negotiations, the demands placed upon the field operations became one of the field commander's biggest problems. Often these demands could not be met without additional technical and laboratory support beyond that available at the scene. To comply with these demands, data and samples were sent to the Los Alamos Scientific Laboratory and other laboratories in the U.S. for analysis and interpretation. This article summarizes the early work done at the Los Alamos Scientific Laboratory and elsewhere in an effort to provide some of the information requested.

PARTITIONING OF THE CONTAMINATION

In an incident of this type the most important information to have as soon as possible is the absolute quantities of material partitioned among the various vectors, modes or regions of dispersal, and deposition. At Thule the important considerations in this regard were:

• The amount of contamination carried aloft in the cloud from the detonation of the high-explosive and fire and dispersed over the general area by the prevailing meteorological conditions.

• The amount deposited on the surface locally.

• The amount deposited on aircraft and weapon debris.

• And the amount in and beneath the ice at the impact point.

Contamination associated with debris would be expected to be distributed beneath, in, and on the surface. Absolute determination of the quantities of contamination associated with each of these vectors or modes of dispersal and deposition was essentially impossible. However, from the practical viewpoint, the most important considerations at Thule were the amount, form, and fixation of plutonium and tritium on the surface in the immediate vicinity of the crash site and in the refrozen ice at the impact point where decontamination operations were technically feasible.

The speed of the plane at impact was in excess of

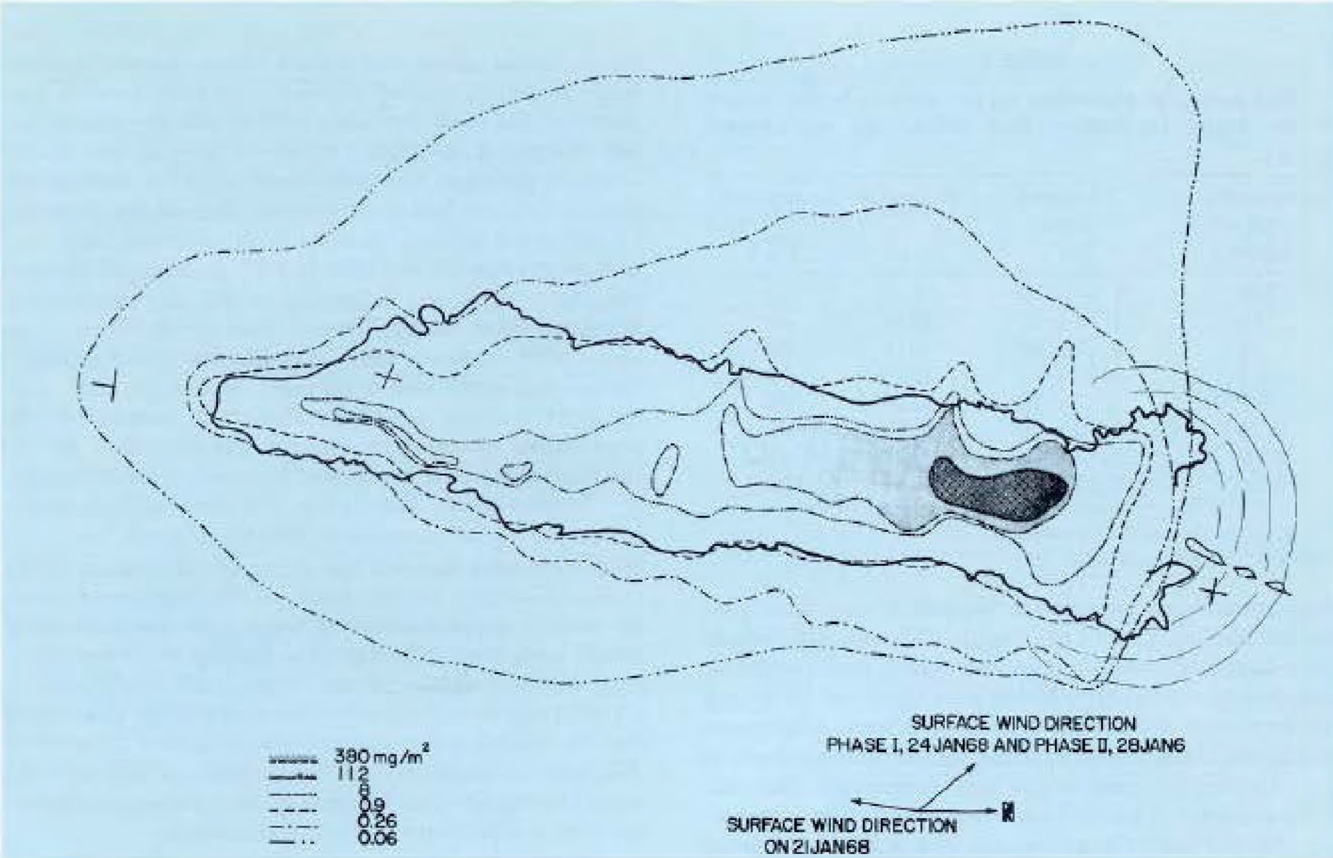


Figure 1 Plutonium contamination levels observed.

500 knots. Its gross weight was about 410,000 pounds—this included about 225,000 pounds of JP-4 fuel. The shallow impact angle and mass and speed of the aircraft resulted in a great forward vector of momentum. When the high-explosive components of all four weapons detonated, the contamination was blown out in all directions and impinged into the materials of the weapons and the aircraft and blown into the splashing, burning fuel. The fuel and much of the debris from the aircraft were catapulted forward on the surface of the ice. When the burning fuel fell back to the surface the fire was soon extinguished, leaving the blackened refrozen crust on top of the snow pack (Figure 1). The ice was completely shattered and disoriented at the impact point and sustained circular cracking out to a distance of about 100 yards in all directions. The peculiar markings on the ice showed the drag and destruction of the left wing, from this the crash attitude of the plane was deduced. From momentum considerations and the pattern on the snow pack, one would expect to find a large fraction of the surface contamination confined to the blackened crust where it was fixed by refreezing of the melted surface. This was indeed found to be the case.

The remainder of the contamination was dispersed in the smoke plume, impinged on the debris of the bombs and the aircraft, and blown into the ice at the site of impact.

CONTAMINATION OF THE SURFACE

Plutonium Distribution and Amount. Simple autoradiographic studies, as well as instrument measurements, established unequivocally that the depth-distribution of plutonium in the snow pack was strictly a function of the depth of blackening and melting of the surface. Over a large part of the blackened area, this depth was no more than about one-half inch. More plutonium contamination was found and its distribution was to a greater depth in those areas where more fuel collected and burned, resulting in more melting of the snow pack. In the most highly contaminated area, the snow pack had melted down to the surface of the ice. Surface distribution of plutonium (other than that adhering to large pieces of aircraft debris which were picked up) is shown in Figure 1. The contours were established by the monitoring teams using the Lawrence Radiation Laboratory Field Instrument for Detection of Low Energy Radiation (LRL FIDLER instrument). Because of the variable thickness of the overburden of ice and snow (complicated further by the two phases of 25 and 28 January), it was necessary to apply different calibration factors to the instrument readings for the areas within each contamination contour. As an example, where the contamination level was highest (380 mg/m²) more fuel had burned and the snow pack had melted down to and even into the ice. Upon refreezing, the

TABLE 1

Distribution of plutonium on the surface in the vicinity of the crash (excluding that picked up on aircraft debris).

Contamination Boundary (mg/m^2)	Enclosed Area (m^2)	Plutonium Deposition* (g)	(%)
380	1.97×10^3	845	27
112	1.10×10^4	2816	89
8	2.49×10^4	3014	96
2.4	3.90×10^4	3079	98
0.9**	5.97×10^4	3109	99
0.26	1.10×10^5	3135	99+
0.19	1.34×10^5	3140	99+
0.06	2.23×10^5	3151	100

*Total out to the specified boundary.

**Edge of the blackened area.

absorption characteristics for the soft X rays from plutonium and americium were quite different than where little depth of melting and refreezing had occurred. Absolute contamination levels were obtained by taking representative samples in each contour area subsequent to a careful instrument reading and returning them to Los Alamos for plutonium and americium analysis. Total amounts of plutonium were obtained by integrating the surface concentration as a function of area (Table 1).

The plutonium values are probably good to ±20 per cent out to the edge of the blackened crust area, which corresponded roughly with the 0.9-mg/m² contamination contour. This information indicated 3150±630 g of plutonium on the surface (excluding that picked up on aircraft debris), of which about 99 per cent was in the blackened pattern and would be removed by removing the snow pack over this area. Assuming removal of the crust and packed snow to an average depth of 4 inches, the volume removed would be 6000 m³ (1.6 x 10 gallons). Assuming further that the volume ratio of packed snow to water is approximately 2.5, this would constitute about 6 x 10⁵ gallons of water, which would contain between 2500 and 37 b of plutonium.

Plutonium-Form, Particle Size and Fixation. It was felt that the ultimate distribution of the plutonium in the event large amounts of the blackened crust were allowed to break up with the ice and go into North Star Bay might be influenced by its form, particle size, and fixation. Detailed nuclear track autoradiographic and microscopic studies of melted crust samples were conducted to obtain pertinent information. These studies showed the plutonium to be in the form of oxide particles with a very wide size distribution. The count median diameter was 2 microns, with a standard deviation of about 1.7. The calculated mass median diameter was about 4 microns. The particles were associated with or adhering to particles and pieces of inert debris of all kinds (metal, glass and nylon fibers, plastic, rubber, flecks of paint, etc.) of all sizes. The mass median diameter of the inert particles with which the plutonium was frequently associated appeared to be at least 4 to 5 times larger than the plutonium particles themselves. Many of the melted crust samples showed the presence of unburned jet fuel. A very crude estimate suggested that as much as 18 per cent (4 x 10 pounds) of the fuel may have remained unburned in the blackened crust. Sedimentation studies showed that up to 80 per cent of the plutonium was associated with low specific gravity debris that remained suspended in the jet fuel. The general feeling was that this fact increased the probability of contamination of the shoreline should the blackened crust be allowed to melt and enter the bay.

Tritium—Form, Distribution, and Amount. Laboratory examination of samples of the snow pack from the blackened area showed the presence of tritium oxide confined largely to the depth of the blackened crust. As water, a major fraction of the tritium contamination would have been expected to be carried away and dissipate with the smoke plume. Only that would remain which condensed on surfaces and nuclei that were rapidly cooled to the ambient temperature (-25° to -35°). The tritium fixed in and on surfaces in this manner would be expected to dissipate at rates that would fluctuate with temperature and wind conditions.

It is not possible to establish tritium surface deposition levels with field monitoring instruments because of the extremely low energy (17.9 kev maximum) of the beta radiation it emits. To determine the amount of surface tritium contamination present with any degree of certainty would have required an extensive and intensive sampling program which hardly seemed justified under the circumstances. It was considered adequate, therefore, to determine tritium in a relatively few samples of the blackened crust to confirm its presence and to establish the magnitude of contamination as assurance that no personnel exposure problems would occur during the operations. Analyses of these samples were considered representative of the areas within the plutonium contamination boundaries (Figure

Table 2

Distribution of tritium on the surface in the vicinity of the crash (excluding that picked up on aircraft debris).

Plutonium Contamination Boundary (mg/m^2)	Enclosed Area (m^2)	Tritium Deposition* (curies)	(%)
380	1.97×10^3	365	27.2
112	1.10×10^4	657	49.1
8	2.49×10^4	986	73.7
2.4	3.90×10^4	1337	100

*Total out to the specified boundary.

l) from which they were taken. Integration of the tritium levels within these boundaries gave a very crude estimate of the distribution and total amount of tritium within the blackened pattern. The results are shown in Table 2 and suggest a total of approximately 1350 curies of tritium confined to the area in the form of tritium oxide. The estimates are probably accurate to ±50 per cent. This amount of tritium would have to be diluted into only 4.5 x 10 m³ of water to be at the maximum permissible concentration for continuous consumption.

CONTAMINATION IN THE ICE AT IMPACT POINT

The ice at point of impact was approximately 3-feet thick. Impact of the plane and detonation of the high-explosive components of the four weapons on board completely fractured and displaced the ice over an area of about 2100 m² (46 m x 46 m). The ice sustained circular cracking without displacement out to about 100 m from the impact point. Isotropic propagation of the shock wave from the high-explosive detonation accelerated a fraction of the contamination and debris from the disintegrating aircraft in the downward direction, impinging it into the fracture area. When fractured, the pieces of ice were displaced downward into the water, randomly oriented, and returned to the surface where they refroze in position. The attitude of the plane at impact was such that essentially all of the fuel was forward and above the weapons. This would be expected to result in the majority of the fuel and contamination entrained from a large solid angle being accelerated up and forward on the surface of the ice by the dominant forward momentum. The general feeling, however, was that additional information regarding amount, distribution, form, fixation, etc., of the contamination of the fractured area was desirable before making decisions as to its ultimate disposition.

Plutonium—Distribution and Amount. A closely spaced core sampling grid was laid out over and around the fracture area (Figure 2), and 49 full-thickness core samples were taken and examined. These cores were studied visually and microscopically and were scanned inch by inch with monitoring instruments. Representative cores were transported to Los Alamos for further study and chemical analyses for plutonium as a means of standardizing the scanning measurements made at Thule. Results showed that the plutonium contamination was usually confined to a narrow band which often could be detected visually because of the associated debris from the disintegrated aircraft and bomb casings. The band of debris with the associated contamination was sometimes on the bottom of the core, sometimes on the top, and sometimes displaced from either end. Some cores showed diagonal bands and others no bands at all. These observations reflected the fact that the fractured ice was displaced downward, returned to the surface, and refrozen in a more or less random pattern with respect to the reconstituted surface.

The fact that cores were scanned inch by inch permitted a crude statistical estimate of the depth-distribution of the plutonium in the ice. It appeared that about 13 per cent of the total plutonium in the crushed and refrozen area was in the top 2 inches, 30 per cent was in the top 4 inches, and 45 per cent was in the top 6 inches. About 15 per cent was in the bottom 10 inches. The remaining 40 per cent was distributed between 6

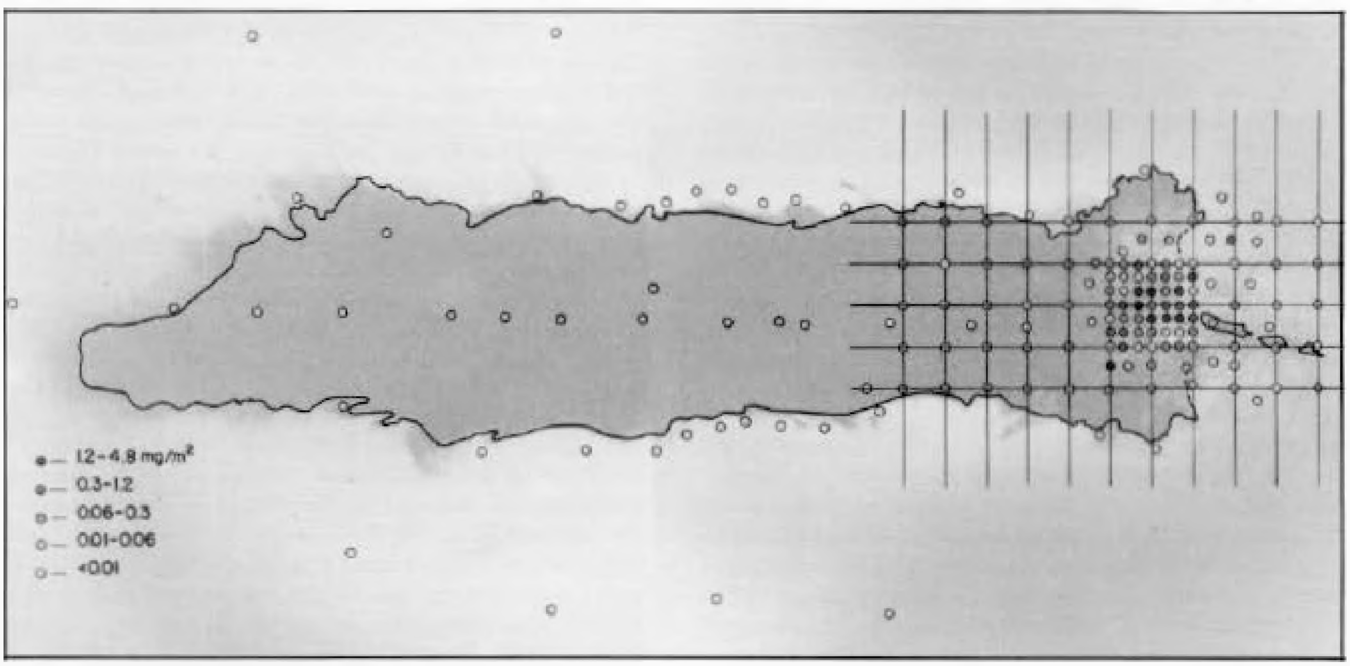


Figure 2 Ice core sample locations.

inches from the top and 10 inches from the bottom.

The plutonium distribution pattern, in terms of contamination per m^2 of surface area, was highly erratic, and it was not possible to represent the results by any simple contour pattern (Figure 2). There was a tendency for the most highly contaminated cores to extend to the back and sides of the center of impact, which might be expected from the relative position of the bombs with respect to the main body of fuel and the crash attitude of the plane. However, cores of comparatively low radioactivity were interspersed among the most radioactive cores, suggesting a highly segregated pattern probably related to reorientation of blocks of ice by the force of the impact and explosion. The random orientation of the rectangular grid with respect to the crushed ice pattern supports the assumption that the cores were statistically representative of the primary impact area in terms of total plutonium and range of local concentrations. Results from the 49 cores showed that 16 per cent contained 65 per cent of the contamination and 52 per cent contained 97 per cent. An estimate of the total amount of plutonium in the fractured ice area (~ 2100 m^2) showed about 350 g. The accuracy of estimate was probably $\sim \pm 25$ per cent. The amount of plutonium in the ice would have to be dispersed in about 5×10^4 m^3 of water to be at the maximum permissible concentration. This is about 60 times the water volume produced by the melting of the porous ice itself.

Plutonium—Form and Fixation. It was felt generally that information on form and fixation of the plutonium in the fractured area might have bearing on questions regarding its ultimate availability to local ecological chains. Microscopic and autoradiographic observations of the residues filtered from melted ice core samples showed fine particles of plutonium oxide impinged into or adhering to pieces of aircraft and bomb casing debris of all sizes. The blackened bands in the ice cores consisted of small pieces of metal, rubber, fiberglass, paint, plastic, etc., up to 1 mm in size to which the plutonium oxide particles were fixed. Sedimentation studies of melted ice cores showed that 85 to 95 per cent of the debris and associated plutonium oxide sank immediately. No JP-4 fuel floated on the surface; only a thin film of fine carbonized material. The remainder of the plutonium was retained on the surface associated with this carbonized film. Only about 1 per cent was suspended through the water phase as very fine particles. This rapid settling of most of the plutonium greatly decreased the possibility of shoreline contamination from floating debris subsequent to melting of the ice.

Tritium—Form and Amount. Only a very few cores from the crushed ice area at point of impact were examined for tritium contamination. The contamination was in the form of oxide, and the amount appeared to be of the order of 17 mCi/m^3 assuming the ice averaged 1 m in thickness. This value, multiplied by the area (2100 m^2), suggested a total of only about 35 Ci of tritium activity in the ice at the point of impact.

CONTAMINATION BENEATH THE SURFACE

A very difficult question involved the possibility that contamination might have been dispersed beneath the ice in a form that could reach the shoreline or be concentrated by some biological process in the local food web. Two possible modes of contamination and dispersal beneath the ice were proposed for examination.

One possibility was that a pool, or pools, of highly contaminated jet fuel might have been trapped beneath the surface near the impact point. To examine this possibility the field teams took an additional 133 core samples, 85 on a grid pattern around the fractured area and over the blackened surface pattern and another 48 outside the periphery of the pattern (Figure 2). None of these cores showed any contamination on the bottom end, and no jet fuel or other floating debris was forced up through the core holes by the hydrostatic pressure beneath the ice.

The second possibility considered for plutonium to have gone beneath the ice was in connection with contaminated aircraft debris that might have been blown through the ice and sunk to the bottom. Pieces of the aircraft found on the surface were transported to Los Alamos to observe the amount, form, and fixation of the associated plutonium contamination. No tritium observations were attempted. Debris consisted of pieces of steel, aluminum, and other materials. Some pieces were highly contaminated on both sides, others on only one side, and still others showed hardly any contamination at all. Due to the numerous unknown quantities and inherent inaccuracies, no attempt was made to determine from the contamination observed on the debris the amount of plutonium that might have gone through the ice. However, later underwater observations during the summer season, dealt with in a separate article in this magazine, established that the aircraft debris which penetrated the ice was stabilized on the ocean floor.

Microscopic and autoradiographic observations showed that the contamination on the pieces of debris consisted of particles of plutonium oxide impinged into or adhering to the surface. Lavation tests in sea water were conducted on contaminated pieces of steel and aluminum to determine removal as a function of time. Different rates were observed for different materials, as well as for different pieces of the same material. The observations supported what might be expected, i.e., that removal rate would depend on the nature and hardness of the surface and velocity of the impinging particles, which would be dependent on the distance of the surface from the detonation. In any event, these observations suggest that, if indeed a large amount of plutonium was carried to the bottom associated with aircraft wreckage, it would not all be released rapidly or at the same time. This would make the possibility of high concentrations at any given time very unlikely.

ATMOSPHERIC DISPERSAL AND GENERAL AREA CONTAMINATION

The amount of plutonium and tritium taken up in the cloud from the explosion and fire and its distribution as long-range or general-area contamination were virtually impossible to predict with the available information. All available data, including cloud height, regional meteorological conditions at the time of the crash and for 10 days after, pyrotechnic information, etc., were sent to the Sandia Laboratory for consideration in view of that organization's experience with nonnuclear detonation experiments. These field tests have resulted in the development of detailed data and calculational models for estimating deposition patterns and contamination levels from nonnuclear detonation of plutonium-bearing weapons. The principal parameters needed are source strength, aerosol characteristics, high-explosive yield, and detailed local and long-range meteorology. Unfortunately, conditions at Thule were such that several of these parameters were either obscured, unknown, or unpredictable. Based on the inadequate information and several assumptions, the Sandia Laboratory was able to draw three general conclusions which are summarized as follows:

- Deposition of the aerosol produced initially would have been expected in a west-southwesterly direction on open ice and Wolstenholme Island. No deposition levels could be estimated, since the source term was obscured by the crash conditions and aerosol characteristics were unknown. However, the original long-range deposition pattern would be expected to be changed under the prevailing phase conditions during the first few weeks after the crash.
- Wind-resuspended contamination probably traveled around and possibly over Saunder Island. However, the condition responsible for the transport made redeposition of much activity on the island unlikely.
- The levels of long-range contamination expected would be radiologically insignificant but, because of the inherent sensitivity of chemical methods, plutonium should be detectable in surface samples taken south and west of the crash site.

Plutonium analyses of surface samples from the principal land masses in the general area are presented and discussed in another article in this magazine.

SUMMARY AND CONCLUSIONS

Immediately following the Thule incident a technical and laboratory support effort was mobilized to comply with requests by the field commander, expert committees, and policy-setting groups for additional technical information and consultation. This effort contributed, in part, to the following factors thought pertinent to the Thule situation:

- Laboratory calibration of field instrument readings and integration of deposition contours at the crash site suggested that the amount of plutonium on the surface was 3150 ± 630 g, approximately 99 per cent of which was confined to the blackened pattern on the snow pack. The plutonium in the crust was in the form of oxide particles, often associated with larger particles of low density inert material which tended to remain suspended in unburned JP-4 fuel. Tritium contamination in the form of tritium oxide was found on the surface largely confined to the blackened crust. The amount present was estimated at about 1350 Ci ± 50 per cent. These observations suggested that removal of the blackened crust and its associated plutonium contamination was desirable.
- Laboratory analysis of representative ice cores taken from the fracture pattern at the impact point, which were related to field instrument scans of other cores from the area, gave an estimate of 350 g of plutonium trapped in the ice. Reorientation and refreezing of the broken ice resulted in a segregated contamination pattern both with respect to depth and area. In this area also, the plutonium was in the form of oxide particles associated with inert debris from the bombs and aircraft. There was little or no unburned jet fuel, however, and upon melting of the ice the contamination did not float or remain suspended. This fact was further assured by covering the entire fracture area with black carbonized sand, which in addition to accelerating melting of this area, absorbed and sank any jet fuel film that might have remained afloat to suspend contamination. The estimated amount of tritium (as the oxide) trapped in the ice at the impact point was about 35 Ci. These and other factors, such as distance of the impact point from shore and depth of the bay, suggested that it was unnecessary to remove the approximately 2,000 tons of ice involved.
- Projection of contamination through and beneath the ice at impact point was considered also. Additional core drillings made throughout the general area of the crash failed to reveal any floating pools of jet fuel trapped beneath the surface.

All contaminated large pieces of aircraft wreckage on the surface were picked up and confined. Laboratory studies were carried out to determine the form, fixation, and lavation rates of plutonium from the surfaces of wreckage. These studies suggested that, if indeed large pieces of contaminated wreckage had broken through the ice and sunk to the bottom, there was little likelihood that high concentrations of plutonium could enter some aquatic factor of the local food web.

- Attempts to calculate meteorological transport and deposition of long-range contamination, although quantitatively unsuccessful, did suggest that contamination levels on land masses south and west of the crash site would be radiologically insignificant but probably measureable by chemical analysis of surface samples.

A report on the Danish Scientific Group investigations, immediate actions and long-range planning regarding the B-52 accident at Thule.

DANISH SCIENTIFIC GROUP INVESTIGATIONS

JØRGEN KOCH
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University of Copenhagen
Counsellor to the
National Health Service of Denmark

AT the meeting in the Ministry of Foreign Affairs in Copenhagen on Tuesday morning (23 January) it was decided at once to send a scientific group representing the Danish Government to the Thule Air Base in order to cooperate with the Disaster Control Team of the Strategic Air Command, and if necessary to carry out independent investigations related to the consequences of the B-52 accident. The group was primarily assigned the task of finding out whether any Danish citizens had been injured as a direct consequence of the crash or by the subsequent fire, either of which might have spread radioactive materials around the point of impact, and in case of such injury to arrange at once for appropriate measures. The ultimate goal of the mission was to assure that no harm could possibly occur to the population living in the area neither immediately nor in the future.

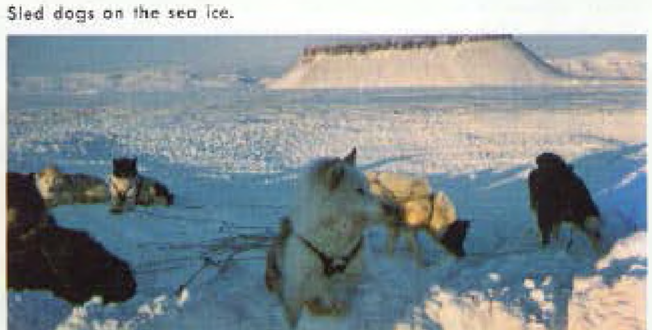
The vanguard of the Danish Scientific Group consisted of the following radiation experts: Henry I. Gjørup, Director of the Health Physics Department, Danish AEC; Per Grande, Director of the Radiation Hygiene Laboratory, National Health Service of Denmark; Professor Otto Koloed-Hansen, Director of the Physics Department, Danish AEC; and Professor Jørgen Koch, Counsellor to the National Health Service of Denmark. Representing the Greenland administration the Group was joined by Hans J. Lassen, Head of Department, Ministry for Greenland.

It was originally planned to use the regular SAS flight bound for Thule on Wednesday 24 January, but due to bad weather conditions departure was delayed until the next day. This delay enabled the members of the group to attend a meeting on Thursday morning with The Honorable Carl Walske, Assistant to the U.S. Secretary of Defense for Atomic Energy, who had come to Copenhagen in order to inform the Danish Government about the accident.

The plane arrived in Thule at about 1:30 p.m. (local time) and was met by the Danish Liaison Officer, Commander Svend Olesen, who introduced the members of the Group to the Air Base Commander, Col Cornelius S. Dresser. Representatives of the Danish as well as of the International press arrived aboard the same plane. It may be added here that the relationship between the group and the press was taken care of by Kaj Johansen, Deputy Permanent Under Secretary of State for Press and Information, Ministry for Foreign Affairs.

In a meeting, which was convened immediately upon landing, Commander Olesen informed the Danish dele-

Sled dogs on the sea ice.



Greenlander in dogsled on the sea ice.

gation about the events which had taken place since the B-52 plane crashed on the ice. As soon as it became known that the bomber was carrying nuclear weapons the potential radiation danger from the spread of plutonium had been recognized. Commander Olesen and Police Inspector F. Skov had been active in the organization of an operation to warn the small number of Greenlanders hunting in the Bylot Sound. The search itself was carried out by Jens Zinglersen (head of the trade station at Dundas), together with a few Greenlanders equipped with dogsleds, who combed the area and asked the hunters to visit the air base in order to be tested for radioactivity. A dramatic situation occurred during this meeting: A telephone call revealed that a Greenlander, Jessi Kujaukitsok, living in a hut at Narssarssuk, had approached the fire as near as possible in order to look for survivors; finding nobody he had returned to Narssarssuk, without having been checked for radioactivity. A helicopter was started right away to clear up the situation. A search for radioactivity in the hut gave a negative result and a few hours later when Jessi Kujaukitsok together with his dogs arrived at the decontamination station, it was ascertained that they too were clean. Consequently, already a few hours after their arrival, the members of the group felt convinced that no injury had occurred to Danish citizens as a direct result of the accident. This impression was later fully confirmed by careful tests of the uptake of radioactivity in the body of the persons concerned.

Later in the afternoon H. Davis Bruner, Assistant Director, Division of Biology and Medicine, AEC, Washington, and Wright H. Langham, Group Leader, Biomedical Research, Los Alamos Scientific Laboratory, who had just arrived from the United States, came to discuss the situation with the Danish Group, and soon afterwards the head of the operation, Maj Gen Richard O. Hunziker, joined the meeting. The General gave an exhaustive description of the situation. However, due to bad weather conditions not too many details could be given, but air photographs revealed that aircraft debris were spread over a drop-shaped area of approximately 750 x 150 m^2, and survey measurements indicated that the major part of radioactivity was confined to this area and partly fixed to the aircraft debris. This information was also given at the press meeting, which was held later in the evening.

A close cooperation between the Danish Group and the SAC Disaster Control Team was thus established from the very beginning. The spirit of joint effort was underlined by quartering the group in a large office located in the Base Service Club, next door to the headquarters of the operation. The members of the Danish Group had unlimited access to the headquarters during the entire operation. Furthermore the Air Attache of the U.S. Embassy in Copenhagen, Col Redgely Kemp, was seconded to support the Danish Group. A secretary was assigned to the group for assistance in the daily work.

The information given to the Danish group upon arrival was confirmed next day by visiting the crash scene. Messrs Gjørup and Koch were brought to the site by General Hunziker, and they were escorted on their 3-hour tour by two members of the Disaster Control Team. Due to the fact that a layer of clean, firm snow had been blown over the area the participants returned without being contaminated to any significant degree.

Meteorological data collected at the local station showed that the heavy storms (phases)—which occur frequently in this part of the Arctic—are generally blowing snow from the ice cap westwards into the Bylot Sound. Transfer of radioactivity from the crash scene to the air base and to Dundas therefore seemed to be very unlikely. This information, together with the fact that the U.S. recovery teams were picking up radioactive debris, indicated that the situation was well under control. On Sunday, 28 January, it was established beyond any doubt that all four bombs had disintegrated following the impact on the ice. The possibility that at least one of the bombs might have passed through the hole in the ice to the bottom of the Bylot Sound, was thereby definitely excluded.

With this background in mind the Danish Scientific Group felt that it was justified to concentrate its main effort on the question related to the radiation levels outside the immediate crash area, since considerable amounts of microscopic particles covered with plutonium might have been injected into the atmosphere and settled down on the shorelines of the Bylot Sound (or even further away), or radioactivity might have been deposited in the seawater, from where it via biological materials could enter the food chain. It was realized that it would be necessary as soon as possible to start long-range planning for the measurements of the spread of radioactivity in order to take care of any eventuality.

As a preliminary precaution, it seemed necessary to warn the population against the potential dangers of entering into the neighborhood of the crash scene. On Monday, 29 January, an announcement was issued by Kaj B. Beck, Head of the municipality at Qanaq, the Reverend Erling Høegh, Chairman of the Greenland National Council, and Claus Bornemann, Governor of Greenland, whereby it was prohibited to stay, or even to pass, the area defined by the following geographical locations: Manson Islands, Mount Dundas, Alanguarsuk, and Inersussat. At the same time a warning was issued against the collection of materials of unknown origin (souvenirs). By request, about a week later, it was decided that hunting of foxes and ravens should be prohibited due to the fact that these animals are inclined to pick up all kinds of materials and to travel far around in the country. These restrictions were gradually relaxed and finally cancelled as the clean-up operation

progressed.

In order to enable the Danish group to cope with the manifold problems mentioned above, further scientific and technical support was requested from Copenhagen. On Tuesday, 30 January, the following experts arrived in Thule: Børge Fristrup, Glaciology, University of Copenhagen; Poul M. Hansen, Marine Biology, Greenland Fishing Investigation; Frede Hermann, Oceanography, Danish Fishing and Marine Investigation; and Christian Vibe, Zoology, University of Copenhagen. Apart from their special fields of competence these scientists are intimately familiar with the area around Thule and they were thus able to give advice on a number of pertinent questions.

At the same time two radiation experts were added to the group: Leif Løvborg and Emil Sørensen (both members of the scientific staff of the Research Establishment Risø). Lt Col Otto Krarup, Chief of Staff to the Island Commander of Greenland, had arrived a few days earlier from Søndre Strømfjord.

Evidently it was of primary importance to make the newcomers acquainted with the location and conditions of the crash site by personal inspection. Already from their first visit on the ice it was possible by observation of the size, form, and position of the ice blocks at the point of impact to confirm the supposition—deduced from infrared photographs—that the 80 cm thick ice had been broken up in an area approximately 50 m. in diameter. Consequently, the presence of radioactive aircraft debris on the bottom of the bay had to be taken into consideration.

As a result of the series of plenary meetings—with the participation of the U.S. representatives, Mr Bruner, Dr Langham, Mr Wolfe and all members of the Danish scientific group—it was decided that further investigations by the Group should be focused on the following topics:

1. Collection of a series of samples of snow and ice from representative locations outside the point of impact, e.g., from the shorelines and the ice of the Bylot Sound, from Thule and Dundas (including the water reservoirs). Sampling should start at the points, which, according to meteorological calculations, seemed likely to be most heavily contaminated.
2. Collection of water and bottom samples, especially with regard to biological materials, which might go into the food chain.
3. Collection of specimens of wildlife such as walrus, seals and foxes, which are used in the household of the Greenlanders.
4. Evaluation of the ice conditions in order to enable planning for the recovery of contaminated ice and snow, and to judge the danger which might arise from the drift of contaminated ice during the following spring.
5. Preparation for a summer expedition with the purpose of checking the region around the entire Wolstenholme Fjord for remaining plutonium.

After having participated in the work for about 1 week, Mr Bruner, Dr Langham, Mr Wolfe, and Mr Kofoed-Hansen left Thule. In order to preserve contact between the U.S. and the Danish scientists, which had turned out to be so advantageous for carrying out the investigations, a meeting was held on Sunday, 4 February, in which a representation of the U.S. health physics team headed by Col Jack C. Fitzpatrick, Field Command Surgeon of the Defense Atomic Support Agency, and all remaining members of the Danish group took part.

At that time contour lines of the spread of plutonium had been roughly determined by gamma ray measurements using the FIDLER instruments, which had promptly been sent to Thule. On this basis it was possible to conduct realistic discussions on the clean-up operation. Details of the above mentioned measuring program were also discussed.

A briefing was given in the meeting hall of the Danish Construction Corporation (DCC) in order to inform the members of the Danish community, who at that time were engaged in civil work at the Thule Air Base (more than 1,000 people) about the consequences of the B-52 crash. Contact was hereby established between the DCC personnel and the health physicists from Risø, who later were stationed on shift in Thule during the entire period of the operation "Pacer Goose." On invitation from Mr Beck and other members of the Qanaq Community Council, a few members of the Danish Scientific Group went to Qanaq by helicopter in order to brief the local Greenland population about the situation.

After having stayed in Thule for about 2 weeks, the Danish Scientific Group felt that its primary mission had been completed. On Wednesday, 6 February, Messrs Fristrup, Grande, Hansen, Lassen, and Koch returned to Copenhagen. A press meeting was arranged at the airport, and it was a relief for all that the situation could be described in reassuring terms, although a number of problems were still not fully explored.

The remaining members of the group stayed another week. Messrs Hermann and Vibe collected a series of samples of seawater and biological materials. Mr Gjørup continued the surveillance of plutonium and organized the health physics duties, which should be carried out during the forthcoming months by his colleagues from Risø coming to replace him.

Other articles detail the work carried out by the Danish Scientific Group during its initial stay in Thule and the subsequent months until the operation was called off. The activity of the group in connection with the summer expedition is described later in this publication.

RADIOLOGICAL MONITORING

CAPT WILLIAM K. McRANEY
Directorate of Nuclear Safety

(Editor's note: Capt William K. McRaney is an Air Force Health Physicist (AFSC 9176) assigned to the Directorate of Nuclear Safety, Kirtland AFB, New Mexico. There are less than 20 Health Physicists currently on active duty in the Air Force. Captain McRaney has a Master's degree in Health Physics/Radiation Biology from the University of Rochester, New York. He responded to the Thule accident as part of the Technical Assistance Team provided by the Directorate of Nuclear Safety, and arrived on site approximately 25 hours after the accident. He remained at Thule 63 days and served as part of the American Scientific Group which provided technical advice to the On-Scene Commander.)

Capt William K McRaney scanning the ice core.

AT any accident involving radioactive materials, the radiation detector becomes a most important tool. Such was the case at Thule where a variety of instruments were employed for both health physics and weapons recovery purposes. In several cases, these applications were rather unique.

The hostile arctic environment created many problems for all aspects of the operation, including radiological monitoring. For example, during the first several weeks of the operation, the outdoor temperature ranged from 20-40 degrees below zero Fahrenheit. At these temperatures carbon-zinc and mercury batteries quickly become useless and the lifetime of alkaline cells is considerably reduced. To combat this problem, all instruments used in the cold were modified with external battery packs that could be worn beneath the operators' clothing. This modification solved the battery problem but somewhat handicapped the operator with troublesome wires. Wires and electrical cables were also affected by the cold, becoming very stiff and brittle. This created an additional burden for the operator as extreme care was necessary to prevent broken cables.

PAC-1S with external battery pack.

Field monitoring problems: Darkness, brittle electrical cables, and bitter cold.

Aerial photograph of the crash site.

Despite these problems, radiation detection equipment was successfully used at Thule and the data obtained played a key role in the operation. This narrative describes the scope of radiological monitoring at Thule, the instruments used, and how they performed.

INITIAL RECONNAISSANCE

The first actual monitoring at Thule was accomplished by a small reconnaissance team of five people. The team size was limited by the only mode of transportation to the site available at that time—five dog-sleds with Greenlander drivers. Their monitoring objective was twofold: (1) to assure, by the absence of fission product beta-gamma radiation, that there had been no nuclear contribution to the accident, and (2) to check for the presence of plutonium contamination. The team took with them an AN/PDR-27 and a PAC-1S. The AN/PDR-27 is the standard low-range beta-gamma survey meter used by the U.S. military services. This is a Geiger-Meuller instrument with a range of 0-500 mr/hr. The PAC-1S is the standard U.S. Army and U.S. Air Force alpha survey meter and uses a zinc sulphide scintillation detector and has a range of 0-2 million counts per minute. The detector probe face has a sensitive area of 59 square centimeters.

Both instruments were operational upon arrival at the crash site but the carbon zinc batteries in the PDR-27 and the mercury batteries in the PAC-1S soon failed in the extreme cold (-30°F). Neither type of battery is rated below 0°F. During the short operational period no beta-gamma radiation was detected with the PDR-27; however, using the PAC-1S, widespread alpha contamination was detected on the surface of the snow, ice, and aircraft debris.

ENVIRONMENTAL SURVEYS

The initial reconnaissance team established the presence of plutonium contamination, the next task then was to determine the degree of contamination and how it was dispersed. The material was largely bound up in a thin frozen crust of blackened ice containing the residue of a fuel fire, some unburned JP-4, and general debris. Also, an arctic storm occurred after the accident and covered some of the surface contamination with fresh snow. Since alpha particles will not penetrate a thin layer of snow or ice, an alpha survey under these conditions would have been meaningless.

PAC-1S with PG-1.

FIDLER

FIDLER detector with thermal insulation.

Low-energy gamma and X rays are associated with the alpha decay of the fissionable materials used in nuclear weapons. For example, plutonium 239 emits a 17KEV X ray and americium 241 emits a somewhat stronger 60KEV gamma ray. Americium 241 is a daughter product of plutonium 241, which is normally present as an impurity in plutonium 239. Therefore, the americium content is a function of the age of the material and the original Pu 241 content. Since X and gamma radiations will penetrate a thin snow or ice cover, an instrument that would be sensitive to these emissions would be very useful.

PAC-1S AGA instruments with PG-1 gamma scintillation probes capable of detecting these low energy emissions were available, but this type of instrument was designed to be a detector only, and would not provide quantitative results. Also, this instrument has a high background count, so fairly large concentrations of plutonium would be necessary before the material could be detected. For these reasons, this instrument was not used.

Soon after the accident, the Lawrence Radiation Laboratory at Livermore, California, volunteered an instrument they had been testing. The instrument was called the FIDLER – an acronym for Field Instrument for Detection of Low Energy Radiation. As the name implies, the instrument would detect low-energy X or gamma radiations from plutonium and americium; moreover, the instrument readout could be related to surface area contamination through a somewhat unique calibration procedure.

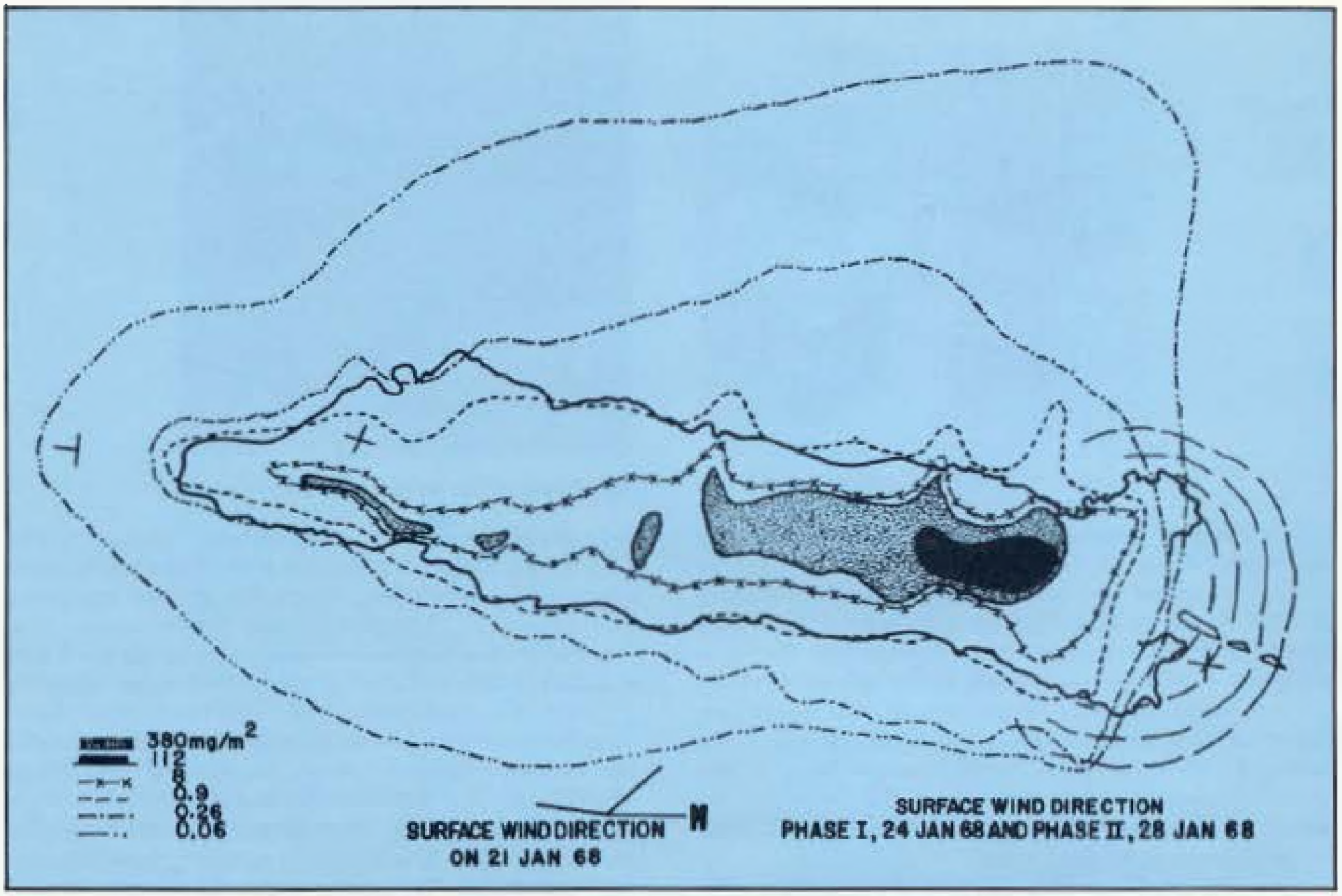
The instrument consists of a PRM-5, a small single Channel analyzer and a scintillation detector. The detector is a 1/16-inch thick NaI(Tl) crystal, 5 inches in diameter coupled to a 5-inch photomultiplier tube through a quartz light pipe. The instrument was modified for arctic use by the addition of an external battery pack and thermal insulation around the detector.

Two days were spent testing the instrument in the field, its performance was satisfactory. Laboratory and field testing had shown that the PRM-5 electronics were temperature dependent, i. e., the proper operating voltage would change with the temperature; consequently, the instrument had to be calibrated and adjusted in the field after at least a 30-minute cold soak.

After the instrument was calibrated, experiments were performed to determine snow attenuation data and the optimum photon energy to monitor – the single channel analyzer permits discrimination of all but the desired photon energy. The americium 60KEV photons produced better instrument sensitivity; therefore, 60-KEV was chosen for survey work. Attenuation experiments showed that 6 inches of snow would reduce the 60KEV photon intensity about a factor of 2.

After this preliminary testing, the first area survey was conducted. Since the data was urgently needed and the weatherman was predicting another storm, a simple 30° radial survey was decided upon. A center point was established and a crude "transit" was constructed to keep the survey on line. The survey team consisted of four men – an instrument operator, a recorder, a transit man, and an operator's assistant to relay data via radio to the recorder, pace off distances, and carry a lantern so that the survey team could be seen and guided by the transit man.

For survey work, the PRM-5 was strapped around the operator's neck to hang about chest height and the detector was carried like a bucket of water at the calibration height of 12 inches above the ground. The detector weighed about 11 pounds and the PRM-5 only 5½ pounds, but after several hours of use they seemed much heavier. A flashlight was also suspended from the operator's neck to illuminate the meter since a built-in lamp is not provided in the PRM-5. The instrument had to be readjusted periodically to keep the electronics set precisely on the 60KEV peak. This was accomplished by fine tuning a small high-voltage adjustment screw on the PRM-5with a tiny screwdriver – a real trick while



Isocontour map of plutonium contamination.

wearing two or three layers of gloves. The PRM-5 has a new type of meter called LINLOG and scale or range switching is not necessary. This proved extremely valuable since operating a small-scale or multiplier switch with these gloves on would have been very difficult.

In spite of these problems, the FIDLER performed well and the first survey was completed in 2 days. More FIDLERs were ordered, but due to a limited supply of PRM-5s and thin 5-inch diameter crystals, only three more instruments could be obtained.

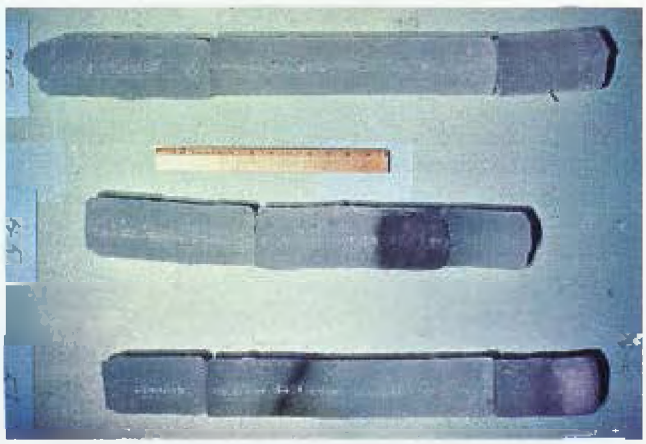
Monitoring teams were trained at Thule to use the FIDLER and the area was resurveyed. This time a 30° radial survey was refined by a grid plot with 50-foot centers. The survey was accomplished using four instruments simultaneously and was completed in 1 day. After normalizing the data from the four instruments, considering snow attenuation factors and comparative data from actual snow samples analyzed in a laboratory, an isocontour map of the contamination was prepared.

The FIDLER was used throughout the clean-up operation to detect "hot spots" missed by the snow removal equipment. The instrument was also used to monitor the tank farm storage area for spills and to conduct the final grid survey of the crash site after the cleanup. The final survey indicated that 93 per cent of the radioactive material was removed from the decontaminated area.

Besides these instrument surveys, a great deal of environmental data was obtained through the laboratory analysis of snow and ice samples. Samples were submitted to the USAF Radiological Health Laboratory, Los Alamos Scientific Laboratory, and Lawrence Radiation Laboratory. A great deal of attention was focused on the immediate impact area where the ice had actually broken. To gain information about the distribution of the contamination in this area, over 150 ice core samples were taken. A crude field method was developed to analyze these cores using the PRM-5 analyzer, PG-1 detector, and a homemade scanner. The ice cores were placed in a wooden box, and using a piece of lead with a 1-inch slit as a collimator, the entire length of the core was scanned at 1-inch intervals. The method was calibrated by comparing scan data with laboratory analyses of a few ice cores. Ice core data proved that significant contamination had not penetrated the ice and that only a small percentage of the total contamination was trapped in the ice at the impact point.

Tritium was detected in some of the snow and ice

Drilling for ice core.



Ice cores from impact area.

Radiological monitoring with FIDLER.

samples submitted to stateside laboratories. Although this did not indicate a significant hazard, laboratory equipment capable of analyzing snow and urine samples was quickly dispatched to Thule. A "Tri-Carb" liquid scintillation counter and operators were furnished by the Sandia Corporation at Livermore, California. Use of this equipment did indeed prove that the tritium present was not a hazard to "Crested Ice" personnel since insignificant amounts of tritium were detected in urine samples taken on location.

A new type of tritium detector was used to monitor the second phase of the operations at Thule, i. e., the transfer of the melted contaminated snow from the large 25,000-gallon storage tanks at Thule to smaller 1,800-gallon containers prior to shipment to the States in the summer. This instrument, the T446 Tritium Alarm Monitor, recently developed by Sandia Laboratories, is a portable instrument comprised of a flow-through ion chamber and a vibrating reed electrometer. The instrument also has a urinalysis capability, the T449 Radiological Urinalyses Kit. The T449 uses a disposable gas generator cartridge to liberate hydrogen (tritium) gas from the urine sample (calcium reduction reaction). The gas is then analyzed by the T446. No tritium hazard was detected during this phase of the operation using the T446/T449.

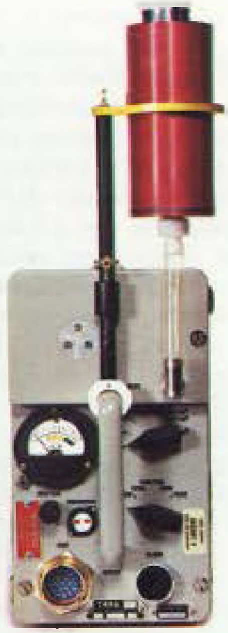
Several buildings at Thule were used for decontamination purposes and one was used to package recovered weapon components. These buildings were continuously monitored by swipe sampling and with PAC-1S instruments. PAC-1S instruments were also used to monitor all tanks or drums containing recovered aircraft debris or contaminated snow and ice. No instrumentation problems were encountered in these programs.

Many air samples were taken at Thule to evaluate the airborne hazards associated with operations such as contaminated snow removal and delivery to the storage area, personnel and equipment decontamination, etc. A hi-volume sampler was used—both 110V AC and 24V DC models were available. Air sample results indicated that resuspension of plutonium was not a problem.

PERSONNEL AND EQUIPMENT MONITORING

A personnel decontamination station was established in a vacant barracks building that contained hot running water and shower facilities. Alpha contamination limits, as measured by a PAC-1S, were established at 450 cpm on U.S. personnel and "none detectable" on foreign nationals. No beta-gamma contamination was detected on the initial reconnaissance team using the AN/PDR-27, and the absence of a nuclear yield was verified by field measurements; therefore, beta-gamma personnel monitoring was unnecessary. This personnel decontamination center grew into a sizable operation with 12 monitors processing up to 200 people a day. A second decontamination station was established at the site for gross work such as removal of anticontamination of

T446 Tritium alarm monitor.



T446 tritium alarm monitor with T449 urinalysis kit attached.

Personnel monitoring at decontamination station.

Nasal swabs were included in the personnel monitoring routine.

clothing, gloves, booties, etc.

Nasal swabs were also included as part of the personnel monitoring routine. These swab results were used as a rough indicator of any airborne hazard and in general revealed no detectable activity. However, since most everyone's nose ran profusely in this climate, there was a reasonable doubt as to the validity of this check.

Everything from dogs and dogsleds to 10-ton trucks leaving the crash site was monitored with a PAC-1S at an exit control point. If possible, all loose snow and ice was removed before the item was monitored. Items found contaminated were labeled and sent to a decontamination station on base where they were washed and monitored again after a drying period. Surfaces had to be dry since any moisture would mask the alpha radiation. Swipe samples were also taken on vehicles and equipment before the item would be released for general use. Contamination limits were agreed upon by Danish and U.S. authorities.

The USAF Radiological Health Laboratory provided a capability to count nasal swabs, air and swipe samples locally. Three gas flow internal proportional counters were set up in the Thule Dispensary. This laboratory equipment proved quite beneficial in providing quick results needed to make immediate judgments.

The PAC-1S was satisfactory for personnel and equipment monitoring considering the problems inherent to any alpha detector. For example, the short range of alpha particles requires that an alpha detector be placed not more than one-eighth of an inch from the surface to be monitored; and direct contact has to be avoided to prevent the probe face from becoming contaminated or punctured. Due to contaminated and punctured probe faces or other malfunctions, up to 20 instruments were required for a full day's operation.

False readings on the PAC-1S occurred occasionally. Static discharges were quite common in this cold, dry climate; this was particularly noticeable since everyone wore arctic clothing made of a mixture of wool and rayon. It was thought that these false readings were due to this static discharge when the detector would make contact with items being monitored. If a reading was due to this phenomenon and not contamination, the meter reading would return to background after a few seconds. This did not create a serious monitoring problem as long as technicians were briefed on the matter.

WEAPONS RECOVERY

Still another application of radiac instrumentation was employed at Thule. The PRM-5 analyzer and the SPA-3 scintillation detector were used in search for weapons components. The SPA-3 detector contains a 2x2-inch NaI(Tl) crystal coupled to a 2-inch photomultiplier tube. This device is particularly suited for detecting 185KEV gamma rays from the uranium 235 used in various weapon components.


PMR-5 with SPA-3.


SPA-3 probes on the weasel.

Although searching by walking and hand-carrying the instrument proved to be the most effective technique, other methods such as suspending the detector from a helicopter and mounting the detectors on a surface vehicle were tried. In the helicopter and vehicle-mounted techniques, the instrument's power supply had to be increased because of excessive voltage drops caused by longer electrical cables. Other instrument problems were caused by vehicle vibration and noise interference.

EQUIPMENT MAINTENANCE

In the past, experience had clearly demonstrated requirements for additional radiac instruments and an on-scene instrument repair capability to support operations. Within this concept, three air-transportable radiac packages were developed for response to this type of emergency. The air-transportable packages were designed to be self-sufficient; each contained 15 complete PAC-1S, two PDR-27, and two PDR-43 instruments (high-range beta-gamma survey meter). Spare parts, and the tools and test equipment necessary for the maintenance of these instruments were included. Two civilian electronics technicians, with one of these packages, were dispatched from the San Antonio Air Materiel Area to Thule immediately after the accident. This proved invaluable to the operation as instrument repairs and modifications were numerous.

At the peak of the activity approximately 70 PAC-1S instruments, four FIDLERS, and three PRM-5/SPA-3 combinations were being maintained. The instrument repair group expanded to four Air Force civilian technicians working two 12-hour shifts. A technician from the Lawrence Radiation Laboratory at Livermore, California, assisted with the PRM-5s and FIDLERs.

SUMMARY

Almost every phase of the operations at Thule depended on radiological monitoring results. The conditions at Thule created many problems in obtaining accurate radiological data both after a few equipment modifications and the use of new instrumentation, but the necessary information was gathered.

The most significant aspect of radiological monitoring at Thule was the use of a gamma detector, the FIDLER, for area survey. Undoubtedly, the addition of this instrument to our kit represents a sizable contribution to the tools of the trade; however, there will always be a requirement for alpha survey meters such as the PAC-1S for equipment and personnel monitoring.


Air-transportable radiac package.


Inside the air-transportable radiac package.

FIDLER ON THE ROOF OF THE WORLD

A FIDLER assembly converted for field use in the arctic.

JAMES BECKER and GARY SHAW
Lawrence Radiation Laboratory
University of California
Livermore, California

DURING the search and recovery phase of Project Crested Ice, a team of scientists and technicians from the University of California Lawrence Radiation Laboratory (hereafter referred to as LRL) advised and aided the Air Force Disaster Response Force in locating and measuring the plutonium contamination and packaging the contaminated debris. Besides the crew at Thule, the Laboratory's facilities at Livermore, California, participated by analyzing data and testing materials that were sent down from the site.

Administratively, the LRL team at the crash site was assigned to the American Scientific Group. Two LRL men—Walter Bennett, head of the Hazards Control Department, and James Olsen of the Director's office—served successive terms as on-site scientific advisors to Maj Gen Richard O. Hunziker, the On-Scene Commander. From the first arrival to the last departure, LRL personnel were at Thule for a total of about 6 weeks. They worked closely with the Scientific Group and helped the Radiological Monitoring Team in data evaluation, sampling, sample counting, electronic maintenance, and in several other areas where they could make a contribution.

LRL became involved in Project Crested Ice via a roundabout route. As one of this country's major weapon laboratories, LRL was immediately notified that an accident involving nuclear weapons had occurred. Since the nuclear bombs aboard the downed B-52 were not of LRL design, we had no direct responsibility in early recovery efforts. But we did have something of value to add to the operation—a staff of experts specifically trained to deal with such nuclear emergencies, and a portable scintillation counter called FIDLER (Field Instrument for Detection of Low Energy Radiation) specifically designed to rapidly survey large areas for plutonium contamination. We promptly notified the Air Force through the Joint Nuclear Accident Coordinating Committee that FIDLER was available; an invitation was extended by the Strategic Air Command (SAC) on 24 January, and within 4 hours two men and two FIDLERs were on their way from California to Greenland. The men were Nathan Benedict, weapon engineer and member of LRL's "Hot Spot" Emergency-Response Team, and Dr. Joseph Tinney, a member of LRL's Hazards Control Staff and the physicist in charge of developing FIDLER.

Because of its importance in getting LRL involved in Project Crested Ice in the first place, we will pause here to explain what FIDLER is and how it came to be. The development of FIDLER was prompted by the incident at Palomares, Spain, in 1966. Although LRL did not participate in the Palomares cleanup operations, our Hazards Control people became aware of the difficulties experienced by the Disaster Response Force in locating and measuring plutonium contamination from the debris covered by sand and water. Clearly, there was a need for a portable instrument that could easily detect and measure plutonium deposition under adverse conditions. Alpha counters, which are routinely used for this purpose, are quite adequate when the contaminating debris is exposed. If the debris is even shallowly buried, however, alpha detection is seriously compromised as alpha particles are not very penetrating.

Plutonium emits low-energy X rays, which are far more penetrating than alpha particles. While these X rays are of such low intensity that they are relatively insignificant biologically, they may be detected using a suitable, sensitive detector. In particular, an X-ray detector should be able to measure contamination that would be "invisible" to an alpha detector. Thus, scientists of LRL's Hazards Control Department undertook to develop a portable instrument for measuring plutonium deposition that operated on the principle of X-ray detection rather than alpha detection.

The result, FIDLER, is basically a sodium-iodide scintillator, about 5 inches in diameter and 1/16-inch thick, coupled to a photomultiplier tube. The signal produced when X rays strike the scintillator is amplified by the photomultiplier and fed to a portable analyzer and count-rate meter.

At the time of the Thule crash, the prototype

FIDLER had been successfully tested at Livermore and under desert conditions at the Atomic Energy Commission's Nevada Test Site, but it had never been tested under conditions anything like those found in Greenland in January. Still, we felt that an X-ray detector like FIDLER would have a better chance of success under the arctic conditions than alpha counters would, particularly since much of the debris was covered with snow and ice.

In the 4 hours that elapsed between our receipt of the invitation from SAC and the departure of Benedict and Tinney for Thule, personnel of the Hazards Control Department converted two prototype laboratory-model FIDLERs into instruments suitable for field use in the arctic. Basically, this conversion involved "ruggedizing" the units against the shocks of transportation and handling, and providing for operation in the severe cold. For example, the battery packs were separated from the rest of the assemblies so that they could be kept warm under the monitors' parkas. The illustration shows the converted FIDLER.

When Benedict and Tinney arrived at Thule, only a few days after the crash, the crash site was still in a primitive state—the support facilities consisted of a wooden shack, and the only light available at that time of year came from Coleman lanterns. The prospect, as Joe Tinney described it, was depressing. But with the cooperation and support of the Air Force Disaster Response Force, Benedict and Tinney managed to calibrate their FIDLERs, check attenuation through various thicknesses of snow, improvise techniques and auxiliary equipment, and start making meaningful measurements of plutonium contamination.

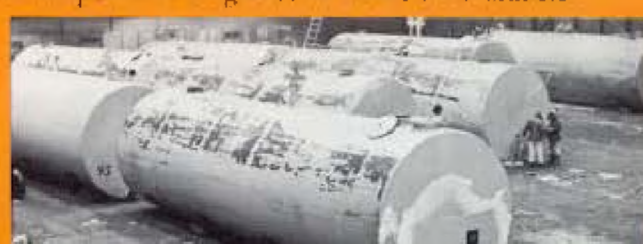
Aside from the natural difficulties of the site, other problems soon arose that were even more critical. For instance, where in Greenland do you find spare parts for a unique and very delicate electronic instrument? Where can you obtain a coaxial cable of just the right size? Where do you take your instrument when it needs servicing? A portion of the Defense Atomic Support Agency Nuclear Emergency Team had been airlifted to Thule on the C-141 aircraft that delivered the Air Force's Air Transportable Radiac Package (ATRAP) with its adequate supply of the standard alpha meters, spare parts and maintenance facilities. The ATRAP, prepositioned by the San Antonio Air Materiel Area at Kelly AFB, included a staff of maintenance personnel who were equipped to maintain standard radiation detection instruments, but there was no store of general testing and repairing equipment. So Benedict and Tinney had to live by their wits until Don Knowles, an LRL electrical technician, arrived with testing equipment, spare parts, and two additional FIDLER units. Wits still came in handy, however, since it was necessary to innovate and improvise in order to cope with the unanticipated conditions that always plague field operations.

Besides the initial work with the FIDLERs in locating and measuring contamination at the crash site, the LRL team rendered important services in connection with the packaging of the contaminated ice, snow, and debris. As the material was initially deposited in drums and tanks, each container had to be assayed to make sure that the aggregate of fissile material could not create a critical configuration under any condition the packages might encounter. Even more important was the need to be absolutely certain that later, when the blackened ice crust was loaded into the 25,000-gallon tanks and melted, a critical mass could not be accumulated.

One member of the LRL team, Milan Knezevich, addressed himself to this criticality problem. He estimated the accumulation of fissile material by monitoring the radiation emitted from each container. To assist and double-check his work, criticality experts at both Los Alamos Scientific Laboratory and LRL made calculations and measurements on samples of known sizes and shapes. By relating all the information that could be obtained from the crash site to the data furnished by the laboratories, the Disaster Response Force was able to establish packaging specifications for precluding a criticality accident.

The huge 25,000-gallon fuel tanks that were used as the interim repositories for the debris presented some ticklish problems of their own. For example, were the tanks strong enough to be lifted and handled after they were filled, or would they break open? Again, LRL's Livermore facility helped to solve the problem. Data from the tank manufacturer's tags and the physical measurements of the tanks were sent to Livermore. With this information, the original specifications for the tanks were obtained from the manufacturer and handling tests were run on mock-ups. Samples of metal from the tanks were also sent to Livermore for metallurgical analysis. The information from these tests furnished the Disaster Response Force with a sound basis for evaluating some of the engineering problems involved in packaging and transporting the debris.

Thus LRL's participation in Project Crested Ice grew from a small beginning into a diverse effort involving men and equipment both at the crash site and at Livermore. We at LRL are glad to have been able to help the Air Force in this sensitive operation, and we feel that the experience we gained at Thule is invaluable.



Fuel tanks in hangar being modified for ice containers.

USAF RADIOLOGICAL HEALTH LABORATORY SUPPORT

COL LAWRENCE T. ODLAND, MD
USAF Radiological Health Laboratory
Wright-Patterson AFB, Ohio

INTRODUCTION

On 22 January 1968, the day after the accident, the USAF Radiological Health Laboratory prepared and shipped its first lot of supplies to support the Strategic Air Command's Disaster Control Team operations on-site.

As investigation of the crash proceeded, and the extent of radioactive contamination became better defined, more definitive Laboratory support requirements evolved.

ON-SITE SUPPORT

The Laboratory provided four categories of on-site support: materiel, equipment, consultation services, and personnel. Materials requested were varied in kind and amount—from three rolls of masking tape to 10,000 envelopes for swipe samples. Containers for ice cores, swipes, and urine samples were the most critical items, since few or no comparable items were available locally. The Laboratory, however, maintains large inventories of all materials needed by field personnel as part of its Broken Arrow response posture. Experience during Palomares and Thule proved the value of this stockpiling, because it permits on-site officials one source for nearly all emergency medical supplies. Thus, pipeline time is limited only by transportation capabilities.

Equipment deployed to Thule consisted of three gas-flow proportional alpha counters and gas cylinders. This equipment was not designed for portability and field use; however, as a result of the experience gained during Crested Ice, the Laboratory designed a portable and automatic counting system in the event the field requirement should be levied again. An additional feature of the new system will be the use of solid-state detectors, thereby eliminating the need for transportation and resupply of heavy, bulky gas cylinders.

Consultation services between the Laboratory staff and on-site staff were conducted by telephone on a daily basis early in the operation, and then weekly as progress continued. However, queries concerning sampling procedures, supply sources, laundry services, and permissible radioactive levels, were usually answered the same day as received. Many times the formation of answers required library research, and the Laboratory staff provided this service.

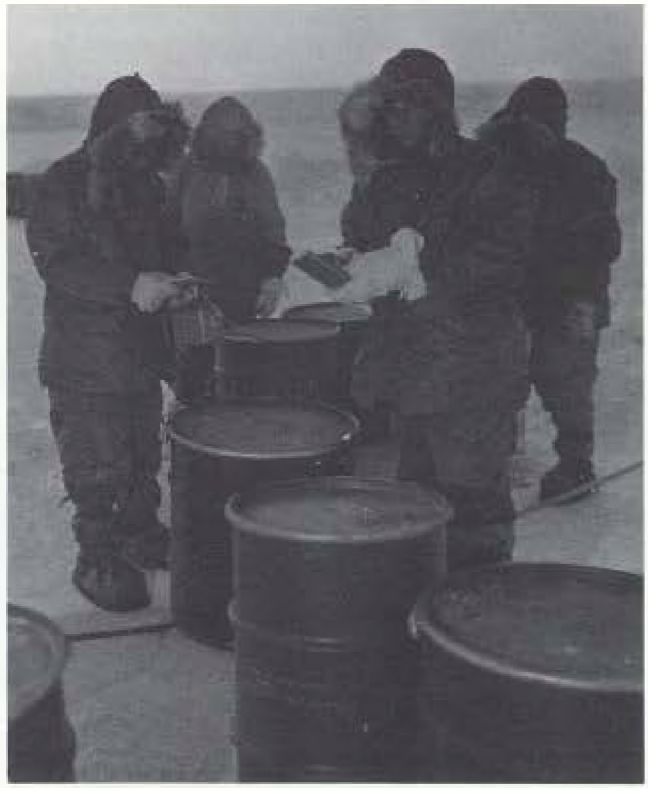
Five staff members—two officers (health physicists), one civilian (electronic engineer), and two airmen (a Preventive Medicine Technician and a Radioisotope Laboratory Technician) from the Laboratory—were deployed to the site in support of the operation. In aggregate this time totalled 220 days, including the periods when contaminated waste was removed from Thule during which a health physicist provided 45 days of on-site consultation services. The enlisted men processed samples and operated the counting equipment, as well as assisting with other details as required. Electronic maintenance support was provided by the engineer. A health physicist served on the staff of the On-Scene Commander during the phase of operations directed by the Strategic Air Command team. His duties included monitoring the crash site for contamination levels, supervising procedures for decontamination of personnel and equipment, advising on hazards and practicability of various proposals for waste disposal, and conducting such special studies as were necessary to answer operational problems.

IN-HOUSE LABORATORY SUPPORT

In this as in all other events of an emergency nature where Radiological Health Laboratory support is required, the entire staff and capability of the organization were placed at the disposal of the Strategic Air Command needs. This was a professional, technical and

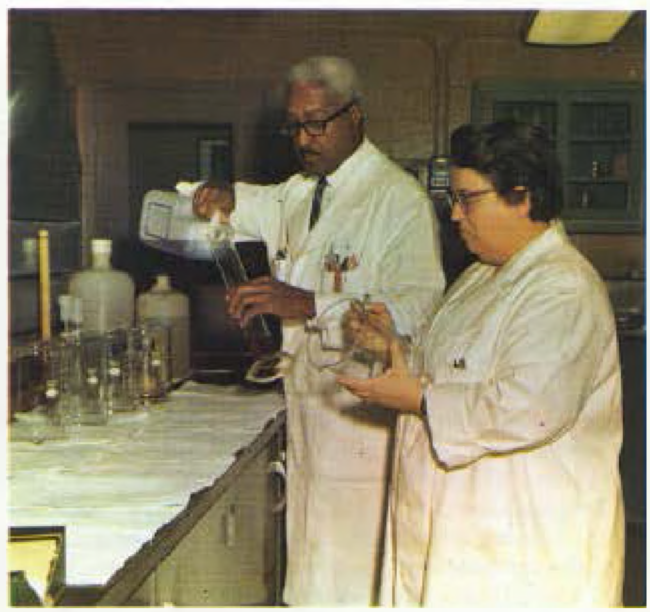
administrative staff of 32 individuals, and over one-half million dollars of laboratory equipment and supplies. Initially, the work load was insignificant, but as clean-up procedures started, samples increased enormously. During one week, nearly 2,000 samples were processed—a figure 10 times that routinely completed. All material processed on site at Thule was reanalyzed at the Laboratory to permit preparation of permanent records for computer processing, and as a quality control procedure. In addition, it was essential that the practicability of field analyses be evaluated for accuracy. In many cases we found duplication of sample numbers and incomplete sample identification data. These deficiencies were corrected by telephone with officials at Thule. The Laboratory also served as the personnel contact agency for submission of urine samples. From the Palomares accident we learned that urine samples routinely collected at the scene for later plutonium analyses were often contaminated with minute amounts of the isotope; thus, it was necessary to resample individuals after their return to base of assignment. As a daily screening procedure at Thule, nasal swipes were taken and immediately analyzed.

Rosters of personnel participating in Crested Ice were prepared at Thule, along with a letter to the individual advising him of the requirement to submit a 24-hour urine specimen to the Laboratory for analysis upon returning to his base of assignment. The Laboratory served as a clearing center to insure that each individual submitted the required sample and, of course, conducted the analyses. In-house analytical services provided results on urine samples for plutonium (^{239}Pu) and tritium (^{3}H), gross alpha counts on nasal and surface swipe samples, specific analyses for certain nuclides in water, soil, rock, snow plankton, dog hair, and air. Over 20,000 separate samples were processed between 22 January and 1 September 1968.



Decontamination team monitoring barrels of debris.

Robert Farr, Electrical Technician, and TSgt Donald Eudy processing nasal swipe samples.



SMSgt Lesly G. Leeder and Kenneth Blackburn begin initial steps in the processing of urine samples in the Laboratory at Wright-Patterson AFB, Ohio.

The results of these analyses are a tribute to the outstanding program designed and implemented by the On-Scene Commander and his staff. The nearly 800 urine samples were uniformly free of ^{239}Pu, indicating that no participant in the operation was internally contaminated with this radioactive material. Each sample was also analyzed for tritium. The highest value found was 1.29×10^{-9} curies. Studies have shown values as high as 30×10^{-6} are of no significance insofar as a health hazard is concerned. Of even greater significance are the results of the nasal swipes. Only 3.5% of the 10,000 analyzed showed any detectable alpha activity. The highest value found was 208×10^{-12} curies. The "action level" or point where internal contamination hazard becomes significant is 300×10^{-12} curies.

One hundred and ten water samples were studied for plutonium and tritium; 246×10^{-9} curies per liter of plutonium and 626×10^{-6} curies per liter for tritium were found. These samples were gathered from known areas of contamination, and the results were provided as additional data upon which to base operational decisions. Over 5,300 surface swipes were taken from vehicles, work areas, containers, etc. The highest level of activity of alpha particles detected was $33{,}000 \times 10^{-12}$ curies. Action levels were set at 200×10^{-12} and decontamination teams took necessary steps to clean up the contaminated surfaces.

Air samples were taken throughout the operation to insure safety to personnel. One hundred and seventy-nine such samples were analyzed. The highest value found was 23×10^{-9} curies per meter^{3}.

In addition, miscellaneous type samples were assayed for radioactivity. Sewage, dog hair, and plankton from the ocean floor showed varying but insignificant amounts of alpha activity. Samples of snow heavily laden with JP-4 contained the greatest amounts of radioactive material — 991×10^{-6} curies per liter of ^{239}Pu and 7×10^{-6} curies of tritium per liter were detected in some of those samples.

SUMMARY

The Crested Ice operation demonstrated the advisability of having one unit with instant response capability for supplies, services, and personnel, able to respond in the event of a nuclear accident. The use of nasal swipes in lieu of routine on-site urine sampling resulted in simplified screening procedures on scene, reduced time to feed back results to decision-making levels, and permitted orderly collection of uncontaminated urine samples far removed from the environment of urgency and expediency that surrounds on-site activities. Deployment of limited Laboratory capability to the scene was very helpful in this case because of the fixed nature of facilities from which operations emanated.

Bagged and boxed ice cores ready for shipment.

Maj Joseph S. Pizzuto and helper bag ice cores for shipment.

INVESTIGATION AND EVALUATION OF CONTAMINATION LEVELS

HENRY L. GJØRUP et al*
Danish Atomic Energy Commission
Research Establishment Risø

INTRODUCTION

SHORTLY after arrival at the Thule Air Base on Thursday, 25 January 1968, the Danish Scientific Group was informed that the chemical explosives in the four nuclear weapons had detonated in the crash, and that their contents of plutonium had been scattered.

The main concern of the Danish group was, of course, to estimate the potential hazard to the inhabitants of the Thule region. Immediate consideration was given to a dogsled driver, Jessi Kujaukitsok, who had observed the accident from a position southwest of the crash site and had moved up to a position east of and close to the fire in order to look for survivors. As a man of common sense, Jessi Kujaukitsok had moved to the east of the big fire because the surface wind was blowing westwards; however, since he had been subject to the risk of contamination, he, his equipment and his home in Narssarssuk were carefully monitored. Results showed they were not contaminated. Monitoring of other persons and dogs that had been moving through the area, or to and from the crash site during the days after the accident, revealed only very slight contamination or none at all. It was, therefore, concluded that the radioactive contamination—mainly plutonium oxide dust resulting from the scattering and burning of plutonium metal in the weapons—was firmly attached to debris and to the crystals of the snow that covered the ice, and that there was no immediate risk of transfer of plutonium to the metabolic system of human beings. Anyhow the group considered it important to determine the distribution and amount of contamination in the environment and at the crash site, in order to evaluate the exposures which might have resulted from airborne contamination during the fire, and which in the future might result from the introduction of plutonium into the food chain.

METEOROLOGICAL CONDITIONS

The first step made to obtain a picture of the accident was to study the meteorological conditions at the time of the accident. On the basis of interviews with eyewitnesses and meteorological and radar observations made at Thule Air Base, Professor O. Kofoed-Hansen concluded that the smoke cloud from the fire had probably drifted towards the south and southeast. The horizontal extent of the fire was about 800 m and the height of the fire column about 850 m. The smoke cloud rose even higher. The atmosphere was very stable up to a height of 830 m due to inversion. At greater heights up to 2,200 m the thermal stratification was still stable. At ground level a slight wind was blowing from the east. The wind direction veered counterclockwise with increasing height: at 1,000 m it was blowing from the north and at 3,500 m from the west. The wind speed was about 3 m/sec at all heights.

Although the finer particles would be carried far away and precipitated in very low, probably undetectable, concentrations, some measurable contamination could be expected in the direction of the hunting huts at Narssarssuk approximately 5 miles south of the crash site, where some 15 Greenlanders lived. Also some activity from the heavily contaminated blackened area might have been resuspended by the snow storms on 24 and 29 January and carried towards the west in the direction of Saunders Island.

ENVIRONMENTAL SNOW MONITORING

The next step was to organize an environmental monitoring program. The kitchen of an unused messhall was made available to the Danish group as a lab-

Figure 1. General view of the mess hall kitchen laboratory.

*Niels Edvard Busch, Physics Department, Hans Flyger, Jörgen Lippert, Herbert C. Rosenbaum and Asker Aarkrog, Health Physics Department, Heinz Hansen, Medical Laboratory, Helmut Kunzendorf and Leif Løvborg, Electronics Department, Bror Skytte-Jensen and Emil Sorensen, Chemistry Department.

oratory (Figure 1) and the first snow samples from the ice in the vicinity of Narssarssuk were collected by helicopter on 28 January. By very primitive means (oral counting of the clicks from an alpha-ratemeter and keeping time with a wristwatch) it was established that the snow samples from Narssarssuk contained long-lived alpha activity, whereas snow samples from the Thule Air Base contained no activity (samples of old snow) or only natural activity in the form of radon and thoron daughters (drift snow deposited by recent snow storms).

The laboratory situation was considerably improved when, by request, additional Risö staff, E. Sörensen and L. Løvborg, arrived on 30 January, bringing with them equipment that included a variety of chemicals, glassware, etc., a solid-state alpha detector, a scintillation gamma detector, a 100-channel pulse-height analyzer, a portable single-channel analyzer, and two alpha scalers. The only thing lacking was suitable evaporation equipment. A search in the Base Exchange revealed some Teflon-coated frying pans, which proved to be ideal for the purpose. They were responsible for the nickname "Operation Frying Pan" given to the activities of the laboratory. It soon turned out that standard analytical procedures were not suited to the actual circumstances, and Sørensen and Løvborg immediately improvised a simple and adequate analytical procedure. The group was further strengthened when Erling Johansen from the Electronics Department and a specialist in environmental monitoring, and A. Aarkrog, arrived from Risö on 12 February, 1969.

The laboratory made it possible to make quantitative measurements. The snow sampling was intensified during the first days of February. It was carried out in a pattern planned in accordance with the existing possibilities of navigation on ice, hence most samples were taken from locations along straight lines. The ice was crossed by dogsleds driven by Greenlanders and by a truck from Dundas. Later on a belt-driven vehicle was loaned to the team by the base commander. The difficult and exacting sampling operations were carried out successfully, thanks to the skill of J. Zinglersen.

At each sampling location, six discs of snow with a diameter of about 15 cm and a thickness of about 3 cm were cut out using an empty sugar can. Before each sample was taken, the inner surface of the can was lined with a plastic bag folded over the edge of the can. In this way cross-contamination between samples was avoided.

The six snow samples from each location were bulked in the laboratory where they were melted and partially

Figure 2. Melting and evaporation of snow samples.

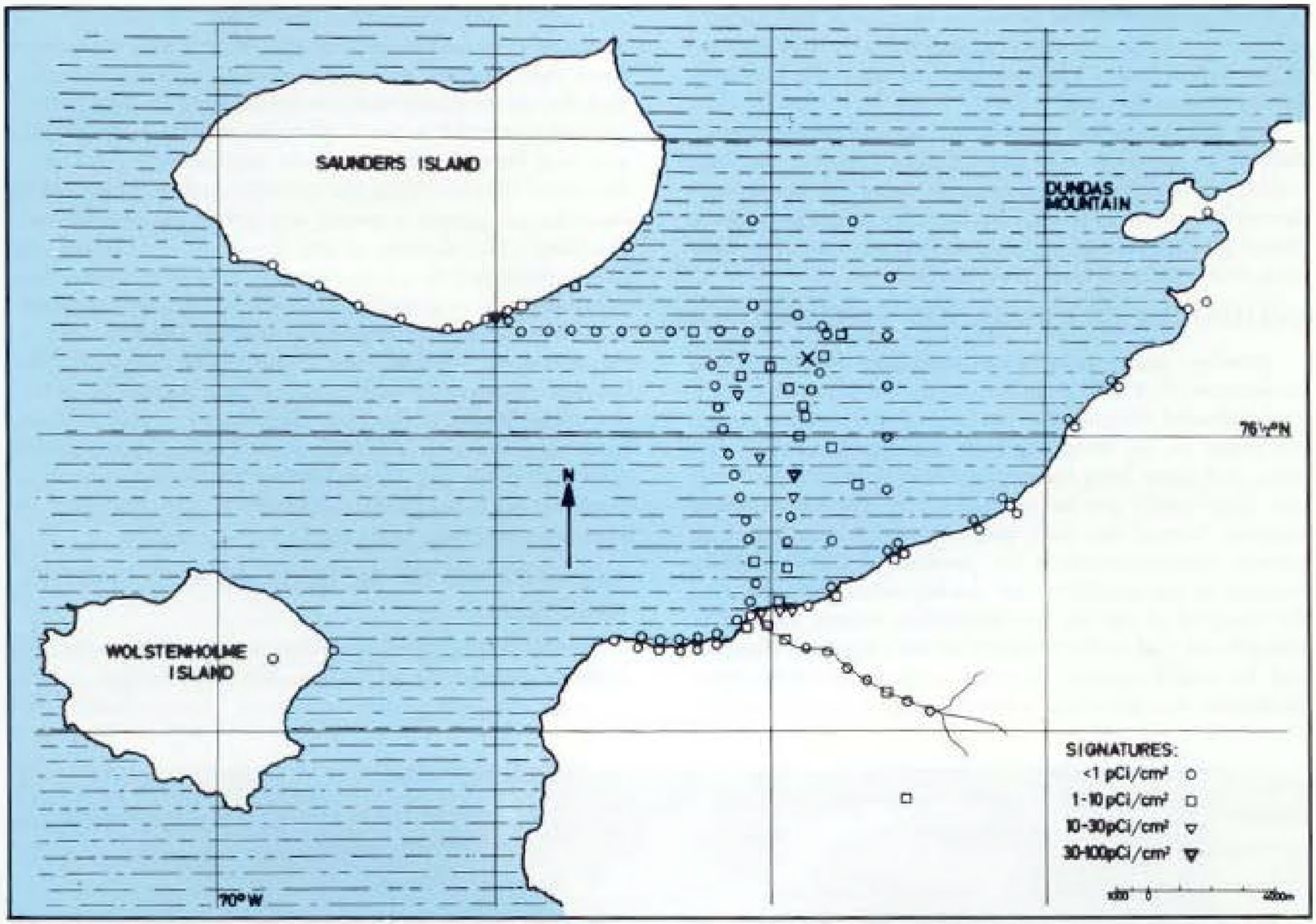


Figure 3. Map of the Bylot Sound area showing plutonium contamination levels. The point of impact is marked with a cross.

evaporated in the Teflon-coated pans (Figure 2). It was found that on filtration of the water from the melted sample through ordinary filter paper, usually more than 90% of the alpha activity was retained by the filter. The few exceptions to this rule were ascribed to the content of salt in some of the samples collected from the surface of the sea ice. After the filtration, each filter was incinerated and the ashes dissolved in HNO_3. The solution was evaporated on a stainless steel disc, and the alpha activity of the disc was measured by alpha counting. By comparison with a standard, the countings were finally converted to contamination levels at the corresponding sample locations expressed as pCi of Pu 239 per cm² (1 pCi=10^{-12} curie).

The sampling locations and the contamination levels (Figure 3) at these locations are shown on the map of Bylot Sound. The first samples were taken along the coastline from Thule Air Base to Cape Atholl in order to find the point of maximum contamination. As expected, it was found in the vicinity of Narssarssuk. However, the contamination at this point was quite low—only 24 pCi/cm²—corresponding to what is accepted in laboratories where the staff is allowed to work for a lifetime. The sampling was continued on the ice of Bylot Sound. The south coast of Saunders Island and the river valley extending inland from Narssarssuk towards the southeast were also sampled.

The program was completed on 18 February after more than 100 snow samples had been collected and analyzed. The contamination was found to be concentrated in two zones, one extending southwards and one westwards from the point of impact, presumably caused respectively by direct fallout from the smoke plume and by resuspension from the blackened area. Generally, the levels, including those quite close to the blackened area, were very low; only at a few points did they reach values of the same order of magnitude as at Narssarssuk. The highest value measured was 40 pCi/cm², and the geometric mean of all samples was about 0.4 pCi/cm². In comparison, the accumulated fallout of Pu 239 from weapon testing is about 0.1 pCi/cm² in the temperate zones of the northern hemisphere. It appeared that resuspension had occurred only to a very slight degree.

The total amount of Pu 239 contamination in the Bylot Sound area—outside the well-defined crash site—was estimated to be only 1-5Ci, and it was concluded

that this amount could be of no biological significance neither as a surface contamination nor as a contaminant of the waters of Bylot Sound later on when the ice cover would gradually melt.

For the sake of completeness it should be mentioned that snow samples from the ice that covered the lake supplying the Thule Air Base with water did not contain detectable amounts of plutonium. Nor was it possible to detect plutonium in samples collected from the base area, from Dundas and from Qanaq.

EVALUATION OF INHALATION EXPOSURE

Another point to be considered was the amount of plutonium that the population at Narssarssuk might have inhaled during the passage of the smoke cloud. Naturally no air sampling had been performed at that time, and since lung measurements are difficult (at any rate they could not be performed at Thule) the snow samples formed the only basis for an evaluation. The surface contamination is the product of the deposition velocity of the particles and the exposure integral, i.e., the integral of the air concentration versus time. The amount inhaled is the product of the exposure integral and the breathing rate. In order to make a conservative (pessimistic) evaluation, a very low deposition velocity (corresponding to very small particles) was assumed and a maximum inhaled amount of 0.05 μCi was arrived at. Even this amount was not considered to be harmful, and the actual value must be much smaller because the particles would have had to be much larger than assumed here in order to have reached the ground at this short distance from the ascending cloud. Moreover, these larger particles would not penetrate deeply into the lungs. The absence of any significant exposure was later confirmed by urine samples. It is difficult to take urine samples in a contaminated area without introducing extraneous contamination, which inhibits correct measurement, because only a very small fraction of the inhaled or ingested plutonium oxide is transferred to the urine. Some of the first samples were slightly contaminated, but later uncontaminated urine samples were collected from the Greenlanders in Narssarssuk—including Jessi Kujaukitsok—which showed that no detectable systemic body burden had resulted.

MONITORING OF BIOLOGICAL AND MARINE SAMPLES

It was considered important to get an impression as soon as practicable of the possibility of contamination through the local ecological system. The environmental

Figure 4. Three deepfrozen polar foxes are received at Risö for analysis.

snow samples were therefore supplemented by biological samples, including polar foxes (Figure 4), seals, walrus, and a dog. Christian Vibe and F. Hermann carried through the difficult task of sampling the seawater and the bottom of Bylot Sound at six different locations—some of them as close as 800 m to the point of impact—and down to depths of about 200 m. Samples of the sea bottom, snails, lugworms, plankton, and seawater were obtained. All these samples were shipped by air to Risø, where they were analyzed by Aarkrog, who returned to Risø on 20 February. Of special interest was a sample of faeces from sled dogs used for transport to and from the crash site. These dogs do not drink water, but eat snow instead. It was remarkable, and very reassuring, that the total quantity of faeces collected (50 g) contained only 100 pCi (10^{-10} Ci). All the other samples contained no significant activity.

COUNTRY-WIDE SNOW MONITORING

This article mentioned earlier that the smoke cloud rose to appreciable heights, and that the finer particles would be spread over long distances and precipitated in very low, and, in all probability, undetectable concentrations. In order to confirm this latter assumption, snow samples were collected by the Greenland Technical Organization from 25 locations all over Greenland, from Nanortalik and Prins Christian Sund in the south, to Dundas and Station Nord in the north. These samples were analyzed at Risø and as expected they did not contain any activity significantly different from the fallout background.

PARTICLE SIZE DISTRIBUTIONS

As already mentioned, the size of particles containing plutonium was of interest in connection with the distribution of fallout from the smoke cloud, the evaluation of exposure integrals, and the penetration of particles into the lungs.

By means of an autoradiografic process an estimate of the size distribution of alpha-active particles in samples of snow from the blackened area, and in crushed and refrozen ice from the impact point was made at Risø by H. Flyger and H. Rosenbaum. Attempts were also made to determine the size distribution in snow samples from Narssarssuk.

Droplets of particle suspensions were deposited on glass slides, which had been freshly smeared with a thin layer of an epoxy resin. The preparations were placed in an oven at 100°C for 1 hour and afterwards covered with a nuclear emulsion stripping film. The total exposure times before development were 30 minutes for the snow samples and 120 minutes for the ice samples. Dark-field microscopy revealed the alpha tracks in the transparent emulsions, and, adhered upon the resin surface, the particles generating these tracks. The particles were sized with an ocular micrometer. Figure 5

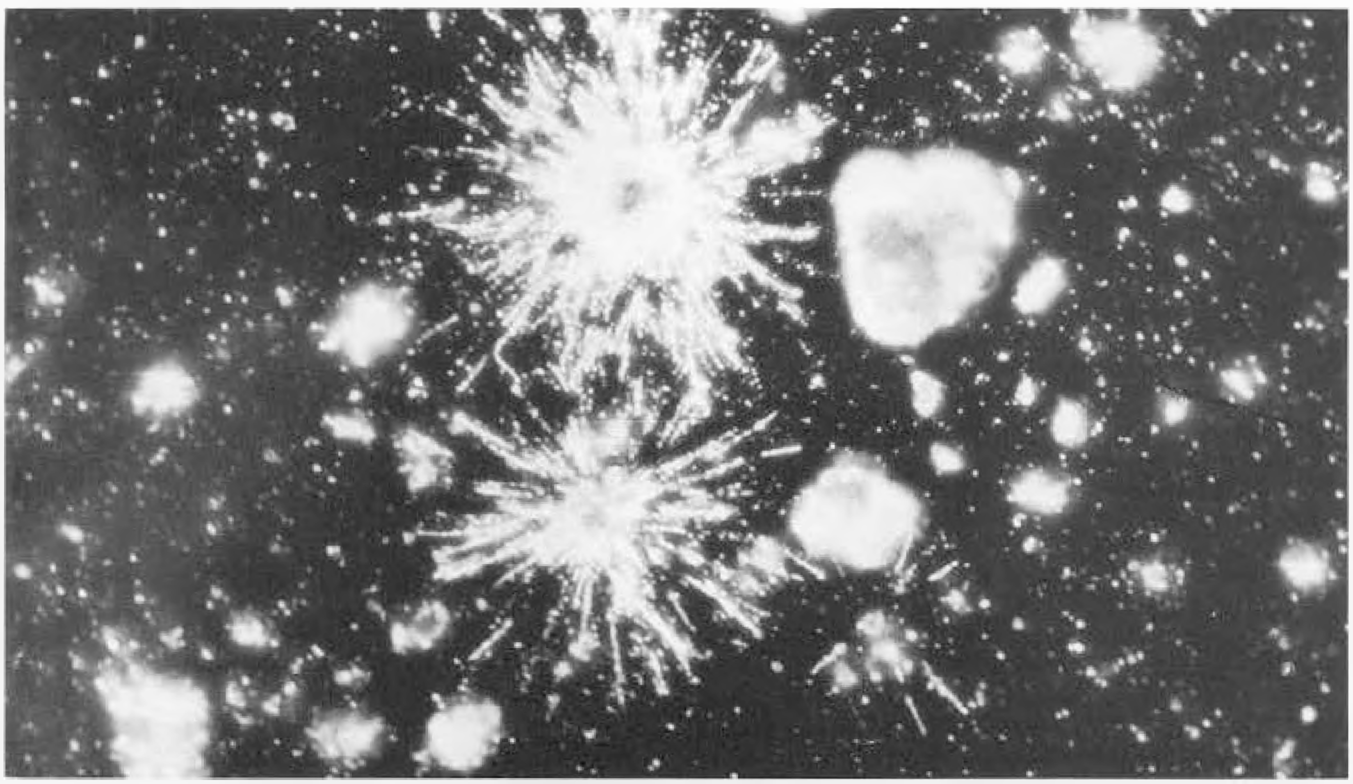


Figure 5. Microphotograph showing alpha tracks from plutonium particles in a sample from the crushed ice.

shows a microphotograph of some of the particles.

In the case of both snow and ice samples, particle distributions near to a straight line on log-probability paper were obtained. The snow samples gave a geometric mean particle diameter of 5.6 microns, and the ice a geometric mean diameter of 2 microns. The diameter of the smallest observed particles was 0.7 micron. The distribution curves were in each case based upon a count of about 100 particles.

The snow samples from Narssarssuk contained too few particles to make a determination meaningful. Meteorological considerations indicate that the fallout particles at Narssarssuk should be expected to have a diameter of around 20 microns.

MEASUREMENTS OF BLACK SNOW AND CRUSHED ICE

Although the total amount of radioactivity carried aloft with the smoke cloud and finally deposited on the ground could not be determined, it was obvious from the environmental monitoring program that the resulting concentrations were so small they could not in any way be considered harmful.

What remained to be done now with respect to district monitoring was to assess the amount of activity left at the crash site, in the black snow crust, on debris, and in the crushed ice. The first ice cores—3" in diameter and approximately 40" long—were taken by G. E. Frankenstein (U.S. Army Terrestial Sciences Center) and B. Fristrup (University of Copenhagen) on 1 February. The cores were manually scanned with a single-channel gamma analyzer by Maj J. Pizzuto and Capt W. E. McRaney from the U.S. Air Force. The results and one of the cores were placed at the disposal of the Danish team. Soon afterwards Mr Frankenstein handed over a sample of snow from a point approximately in the center of the black patch. From rough measurements of these samples with the gamma-multichannel analyzer in the kitchen laboratory, it was estimated that the amount of Pu 239 remaining in the ice and on the blackened area was a few kilograms. This estimate was of course very uncertain because of the scarcity of samples available at that time, but later measurements showed that it was not too wide off the mark.

At the beginning of February a systematic ice core sampling program was started by the American Ice Reconnaissance Team. More than 180 ice cores were taken, and they were all scanned in the same way as those first obtained. All the scanning results and 12 representative ice cores were placed at the disposal of the Danish group. The problem of storing these cores in a secure, cool place was solved by the base commander, who allowed the old disused jail at Thule Air Base to be used for that purpose. On 12 February the cores were sent by air to Risø in plastic bags, packed in a wooden box lined with dry ice.

Meanwhile an apparatus for making continuous gamma scannings was constructed by the Electronics Department at Risø, where H. Kunzendorf was performing the gamma measurements. Roughly this apparatus consisted of a 2 m-long plastic tube with a diameter somewhat larger than that of the ice cores and mounted in a heat-insulated wooden box placed on an iron frame together with a chain-driven feed mechanism for the ice core holder.

The ice cores were packed in an additional plastic bag to prevent contamination of the tube, and the box was filled with dry ice to keep the cores frozen. During the scanning process the cores passed the 10 x 50 mm slit of a 5 mm-thick cylindrical lead collimator, which surrounded a 2" x 2" NaI(Tl) integral-line scintillation crystal. The channel of a single-channel analyzer was set at 60 keV, the main photon energy emitted in the decay of Am 241, which was present as a decay product of Pu 241. The pulses were fed to a rate meter and to a recorder.

The box with ice cores was stored in the hot-cell building, and the measurements were carried out here to prevent contamination of the health physics laboratories, where low-level measurements were to take place.

The measurements of the 12 ice cores were repeated by setting the channel of the single-channel analyzer at approximately 17 keV, the energy of L X-rays emitted in the decay of both Am 241 and the Pu-isotopes. The shape of the scanning curves was similar to that obtained when the channel was set at 60 keV, although a thinner scintillation crystal is to be recommended in this energy region.

A comparison between the American and the Danish gamma-scanning results from the same cores showed excellent agreement, and it was therefore possible to utilize the American scanning curves for other cores in the evaluation of the plutonium content of the crushed ice.

The determination of the actual content of Pu 239 in the ice core samples was carried out in two different ways. One way was to measure the content of Am 241 in concentrated samples by gamma spectroscopy and determine the ratio of Am 241 to Pu 239 by alpha spectroscopy. The other way was to determine the plutonium content directly by chemical separation and alpha counting. The gamma spectroscopy was carried out in the Electronics Department by Kunzendorf and Løvborg, who also performed the alpha spectroscopy in collaboration with J. Lippert of the Health Physics Department. The chemical separations were carried out by B. Skytte-Jensen of the Chemistry Department.

The problem of isolating the plutonium in the ice core samples was attacked by drawing on the experience of the analytical chemists at Eurochemic, Mol, Belgium, and on our own experience of solvent extraction with acyl pyrazolones.

The melted ice samples were first filtered through

fluted filters, and the containers were cleaned with pads of cotton. The filtrate was then passed through millipore filters, which allowed only insignificant amounts of a-activity to pass through. The plutonium was contained in a mixture of jet fuel, soot, silicone oil, and minute fragments of plastics and insulation materials from the aircraft. The greater part of the plutonium was in the form of very sparingly soluble plutonium oxide.

Thus the standard procedures for plutonium analysis were not applicable, and it was necessary to develop a new and rapid method.

The fortunate circumstance that a pyrosulphate melt rapidly dissolves plutonium oxides and quantitatively converts plutonium to the tetravalent state, and the fact that the acyl pyrazolones are capable of extracting tetravalent plutonium ions from sulphate-containing media were the basis for the method developed.

The combined filters and cotton pads were destroyed by treatment with hot nitric acid containing acid potassium sulphate (10 g); to this mixture 30% hydrogen peroxide was added cautiously to avoid excessive foaming. It was possible to speed up the destruction by the addition of small amounts of cupric salts. When the vigorous destruction reaction of organic matter had ceased, the mixture was evaporated to dryness in a quartz crucible and then heated to 300-400°C for 10-15 minutes whereby the acid potassium sulphate melted, forming a pyrosulphate melt. During this treatment the last traces of organic matter were destroyed. After cooling, the solidified melt was dissolved in 1 N nitric acid and an aliquot extracted by means of a 0.1-0.05 M solution of 1-phenyl-3-methyl-4-benzoyl-pyrazolone-5 in xylene.

The advantage of this reagent over commonly used extractants such as TTA, etc., is that it can effectively compete with sulphate ions for the tetravalent plutonium ions. A practically quantitative transfer of the plutonium to the organic phase occurred. Samples for alpha spectroscopy were prepared by the evaporation of aliquots of the organic phase on stainless-steel discs and subsequent heating to destroy any excess of reagent. The alpha spectra obtained were of excellent quality with well-resolved peaks.

A total analysis including destruction of organic matter could be made within 10 hours.

The result of the Risø measurements was that the crushed ice contained approximately 20 curies or 320 grams of Pu 239.

On 6 March, O. Walmod-Larsen, who had taken over the Danish health physics duties at Thule, shipped 16 samples of black snow from Thule to Risø. These samples were analyzed in the same way as the ice cores. Unfortunately they were not quite representative of the blackened area (60.000 m²)—especially samples from the most contaminated parts of the black patch were lacking. The Danish estimate of 70 curies (1200 grams) of plutonium in the black snow crust is therefore a minimum value. The actual value was supposed to be two or three times as high, and is thus not in disagreement with the far more extensive American measurements made with the FIDLER (Field Instrument for Detection of Low Energy Radiation) instrument by the team from the Lawrence Radiation Laboratory.

The tritium content in the samples of black snow, where the concentration was appreciably higher than in the crushed ice, was measured at Risø by H. Hansen of the Medical Laboratory. The highest value measured was 47 mCi/m² or 2.7 mCi/l. This means that, as far as tritium is concerned, in a year a man might ingest the tritium contained in 5 sq. ft. of the black snow crust or drink 2 gallons of the undiluted meltwater without exceeding the maximum acceptable intake recommended by the ICRP for occupational workers. This is a farfetched example and even if the tritium concentration in places might be 10 times as high as the highest value observed, it was concluded that tritium could not be considered a hazard.

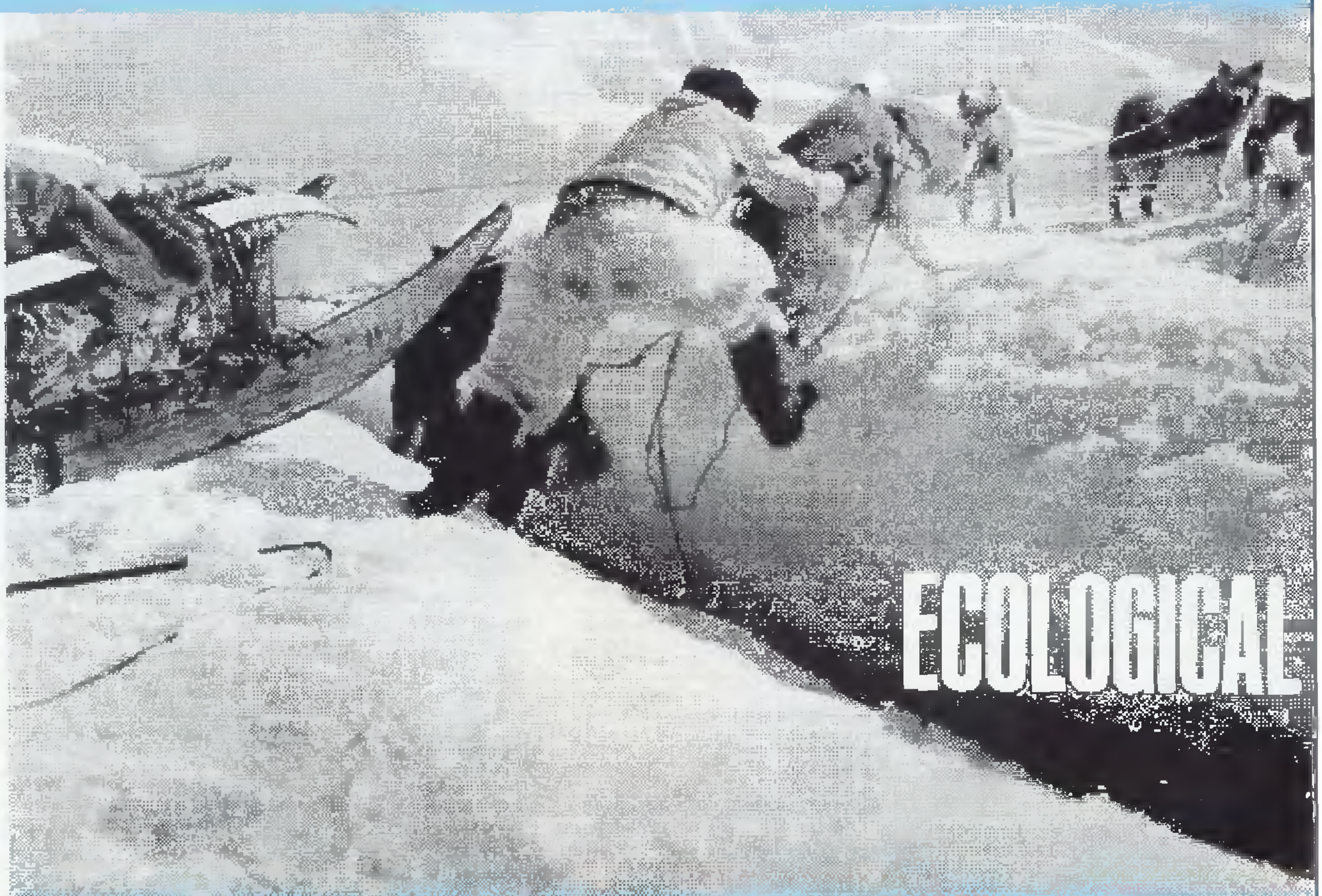
PENETRATION THROUGH THE CRUSHED ICE

For the following three reasons it was considered to be fairly certain that the amount of activity injected into the water through the crushed ice was relatively small. For one thing it was impossible to detect any activity in the bottom samples taken by Messrs Vibe and Hermann in February 1968. For another the activity in the contaminated ice cores was associated with straight dark bands in the ice. These bands appeared to be identical with the top layer of snow that had covered the original surface of the ice before it was broken up into blocks and pieces, churned around, drenched with water, and refrozen in random positions. Finally, the bottom 2 inches of the ice cores, which consisted of new ice formed after the accident, contained no floating debris, dark material, or jet fuel or oil, and no americium or tritium could be detected in this part of the cores. The cores taken outside or at the rim of the crushed ice were uncontaminated all the way through.

The radio-ecological investigations made during the summer of 1968 confirmed that the amount of activity in the marine environment was quite small.

CONCLUSION

The amount and distribution of plutonium in the Thule area after the accident was such that it could not be assumed to be of significance to the health of the inhabitants. As a consequence of the decision to remove the black snow crust—made at the meeting in Copenhagen on 15 and 16 February between U.S. and Danish officials and scientists—the amount was substantially reduced. Even so it was decided to make a radio-ecological investigation in the summer of 1968 to confirm the above mentioned assumption, and to exploit the opportunity presented here to obtain new knowledge about the radio-ecology of plutonium.



THE area of the B-52 accident is situated in the middle of the Thule district which stretches from Melville Bay to the Kane Basin. As of 1 January 1967, this area was inhabited by 538 natives as well as a small number of Danish officials. (This does not include Dundas and Thule Air Base.) These people's only way of living is hunting seals, walrus, narwhals, white whales, foxes, polar bears, and seabirds. There are only two settlements near the site of the accident: Narssarssuk, on the southern side of Bylot Sound, with two families, and Manitssak on the northern side Wolstenholme Fjord with 6-8 families.

Below is a survey of the mammals, birds and lower animals which form part of the food chain in this area, that are of interest in the B-52 case.

LOWER ANIMAL SPECIES ON THE SHORE.

The beach is made up of rocks, here and there broken up by flat areas of sand, pebbles and stones mixed with clay. In the ebbing zone between the high and low tides, only very few lower animal species are found; important are amphipods *Gammarus* and *Pseudalibrotus*, the *Margarita* snail and the bivalves *Mya, Saxicava, Modiolus*, and more rare *Mytilus*.

During low tide, these animals hide under stones in rock crevices or under seaweed, which is only visible during low tide.

LOWER ANIMAL SPECIES ON THE SEA BOTTOM.

The sea bottom in North Star Bay and in the fjord consists of very fine clay, which in some places near the

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BACKGROUND

coast is mixed with sand and pebbles.

Bottom animals are found in the bottom material and on the bottom surface from the water's edge down to the greatest depths in the crash area, approximately 235 meters (approximately 771 feet).

In 1936, at a depth of 14 meters (approximately 46 feet) in the bay itself near Dundas, 41 lower animal species were demonstrated, among them eight species of bivalves, but the fauna is far richer than this as later investigations have revealed. In 1939-41, near Saunders Island and northward in the vicinity of Inglefield Fjord, at depths between 0 and 54 meters (0 to 177 feet), 151 lower animal species were found to be living on the sea bottom and in the free masses of water, including 20 species of bivalves, 23 species of snails, 16 species of *Polychaeta* and species of *Crustacea*, as well as several species of *Echinodermata* and corals. On the walrus banks the density of bottom animals amounted to 450 grams per square meter.

SEA PLANKTON.

The production of phytoplankton begins in the spring with the return of sunlight and the dispersion of the ice. It can be extremely abundant, especially near the birds cliffs on Saunders Island, where the sea is fertilized by bird excrement.

Zooplankton can be found the year round from the bottom to the surface. In winter, the greatest amount is found near the bottom, where the water is warmer and saltier than at the surface under the ice. The zooplankton thus consists mainly of *Sagitta, Aglantha*, but also *Calanus* occurs numerously. In the summer, there are several species of *Medusas, Stenophores, Pteropodas, Euphausians, Copepods, Amphipods,* and fish larvae, and at the lower depths Amphipods and Mysis are found in large quantities along the beach.

THE IMPORTANCE OF THE LOWER ANIMAL SPECIES IN THE FOOD CHAIN.

The phytoplankton is consumed by zooplankton animals as well as by many of the bottom animals.

The zooplankton is eaten by many lower sea animals as well as, in particular, by the *Boreogadus saida*, the little auk, and certain other seabirds.

The *littoral fauna* is eaten by various waders, sea gulls, ravens and white and blue foxes.

The sea bottom bivalves are eaten by the walrus (in depths of 5 to 80 meters [16 to 262 feet]), and by eiders and long-tailed ducks (in the lower depths), as well as by man who occasionally collect *Mytilus* and *Mya* along the beach during the lowest ebb. Man also eats undigested bivalves (*Cardium, Mya* and *Saxicava*) from the stomach of the walrus.

The larger species of *Crustaceans (Euphausia, Themisto)* in the zooplankton are eaten by ringed seal. The larger species of *Crustaceans* on the sea bottom *(Amphipods, Decapods)* are eaten by ringed seal and narwhal, the smaller ones by the eider, and the long-tailed duck (in lower depths).

FISH.

The *Boreogadus saida* occurs in large quantities in the water area between the bottom and the surface, according to where the most food is to be found, especially plankton. There are a number of species of bottom fish of the families *Liparidae, Lycodidae, Cottidae*, et al., the more rare *Reinhardtius hippoglossoides* and *Somniosus microcephalus*, and in July and August *Salvelinus alpinus*.

During the winter, the Greenlanders catch some *Reinhardtius hippoglossoides* from the ice, but only in the south at Melville Bay and northward in the Inglefield

Fjord. *Salvelinus alpinus* is caught during the summer in McCormick Fjord, more rarely in other places. A few *Somniosus microcephalus* are caught through holes in the ice for dog food, and *Cottus* is likewise caught during the spring for the same purpose.

There is no commercial or shrimp fishing in the Thule district.

WHALES.

The white whale and narwhal usually occur in the Thule district and are caught by the population from June until October. During the winter some whales stay in the ice free water of Baffin Bay, but the majority migrates to the south.

In rare cases, the Greenland whale (Bowhead) is observed during the spring, while the killer whale occasionally appears in herds during the summer, usually in the Inglefield Fjord. These whales rarely go into North Star Bay. The most important hunting ground for whales is Inglefield Fjord.

The white whale lives on *Boreogadus saida* and *Reinhardtius hippoglossoides*, the narwhal furthermore feeds on the larger *Crustaceans* of the sea bottom.

The Greenlanders eat the skin of whales (mattak), as well as the meat, blubber, heart, kidneys and liver.

SEALS.

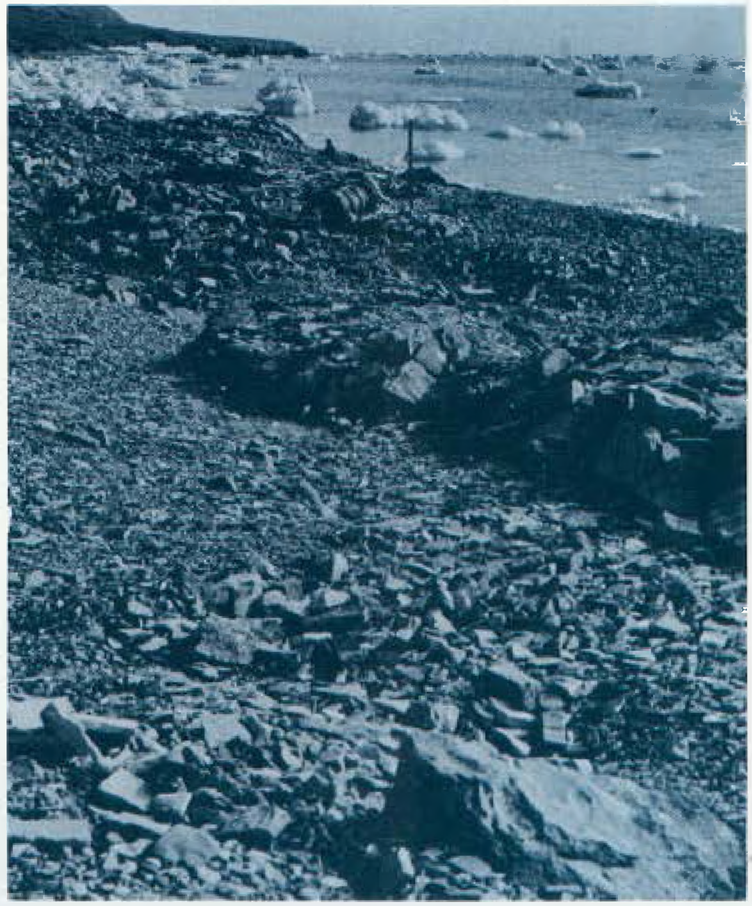
The seals found in the Thule district are the walrus, the bearded seal, the ringed seal, and the harp seal.

The walrus is one of the most important animals hunted in the Thule district—a couple hundred are caught each year. The meat, liver, diaphragm, kidneys and heart are consumed, and at times also some of the contents of the stomach (bivalves).

A small section of contents from a walrus' stomach. This walrus has foraged at 70-80m depth. (Top to bottom): Rows 1 through 5 are siphons of *Saxicava arctica*; Rows 6 through 9 are of *Mya truncata*; Row 10 contains 1 foot of *Cardium groenlandicum*, 2 of *Macoma calcari*, 10 of *Astarte borealis*, 1 of *Cucumaria*, 1 *Priapulus* and 1 *Psolus*.

The most important feeding ground for the walrus is the stretch between Cape York and Etah, where it stays within the outer coast where the depths do not exceed around 80 meters (approximately 262 feet), and where the bottom consists of pebbles mixed with clay inhabited by bivalves (*Cardium*, *Mya*, *Saxicava*, *Macoma* and *Astarte*). It also often eats ringed seals.

The walrus spends the winter in the northern district (Inglefield Fjord) and stays out along the edge of

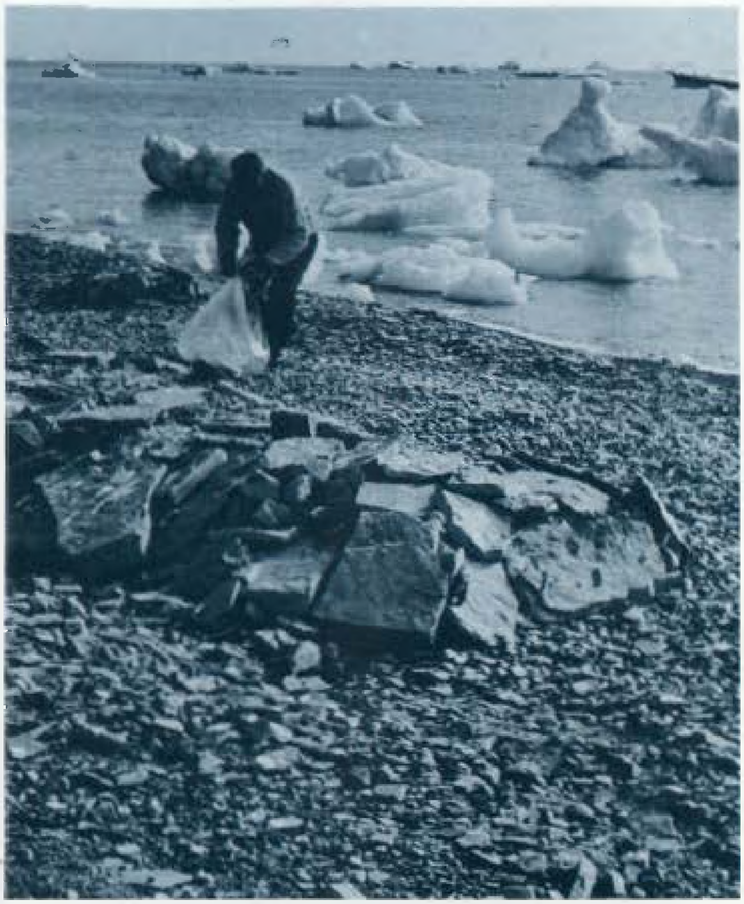


Greenlander walrus depots on the southern beach of Saunders Island, summer 1968.

the ice. It does not go up through ice which is thicker than about 10-15 cm., and it does not go down to depths greater than approximately 80 meters (approximately 262 feet). Thus, the walrus does not occur in the area of the crash where the ice in January is 80 cm (31 inches) thick and the depth is 235 meters (approximately 771 feet).

During the month of July, walrus swarm up from the south. They stay along the outer coast and rarely come closer into the fjord than to the eastern tip of Saunders Island. By end of July they continue northwards to Murchison Sound and the shores of Smith Sound.

The bearded seal is common in the Thule district during summer and winter and is eagerly hunted by the population. They eat its heart, kidneys and liver, and cut up the skin for straps and harpoon lines and the like. The bearded seal eats everything except bivalves. Its most important food is the *Boreogadus saida*, *Cottus* and other fishes from the sea bottom, as well as large snails (*Buccinum*) and *Crustaceans*, but also animal species such as *Cucumaria*, *Psolus* and *Rossia*. During the summer it lives all over in the fjords, but during the winter only near the outer coast, since it cannot maintain its breathing-hole open through ice thicker than 20-30 cm (approximately 8 to 12 inches). Therefore, bearded seals were not in the impact area at the time of the crash.



The ringed seal is the most common seal hunted in great numbers by the Greenlandic population. It occurs in the sea and in the fjords both summer and winter, and it can keep its breathing-hole open through 1 to 2 meters (approximately 3 to 6½ feet) of ice. Its food in the Thule district consists mainly of the *Boreogadus saida* and other fish, but also *Crustaceans* constitute an important part of its nourishment. This seal is found in the area of the accident, winter and summer. From April until June, ringed seals can be seen lying on the ice next to the breathing-hole. They sleep here during the warmest hours of the day, but only for brief periods at a time. When the ice drifts out, most of the ringed seals move to the glacier edge of Wolstenholme Fjord, where the seal hunting then takes place.

During the month of June, the harp seal comes in swarms from the south where it breeds on the drift ice off Newfoundland. Its most important habitat in the district is Inglefield Fjord between Qanaq and Siorapaluk, but it can be found in smaller numbers everywhere. It feeds on fish and *Crustaceans*. It leaves the district with the beginning of the ice formation in September and October. During the time it is available, the population hunt it a good deal. They eat its meat, liver, heart, and kidneys.

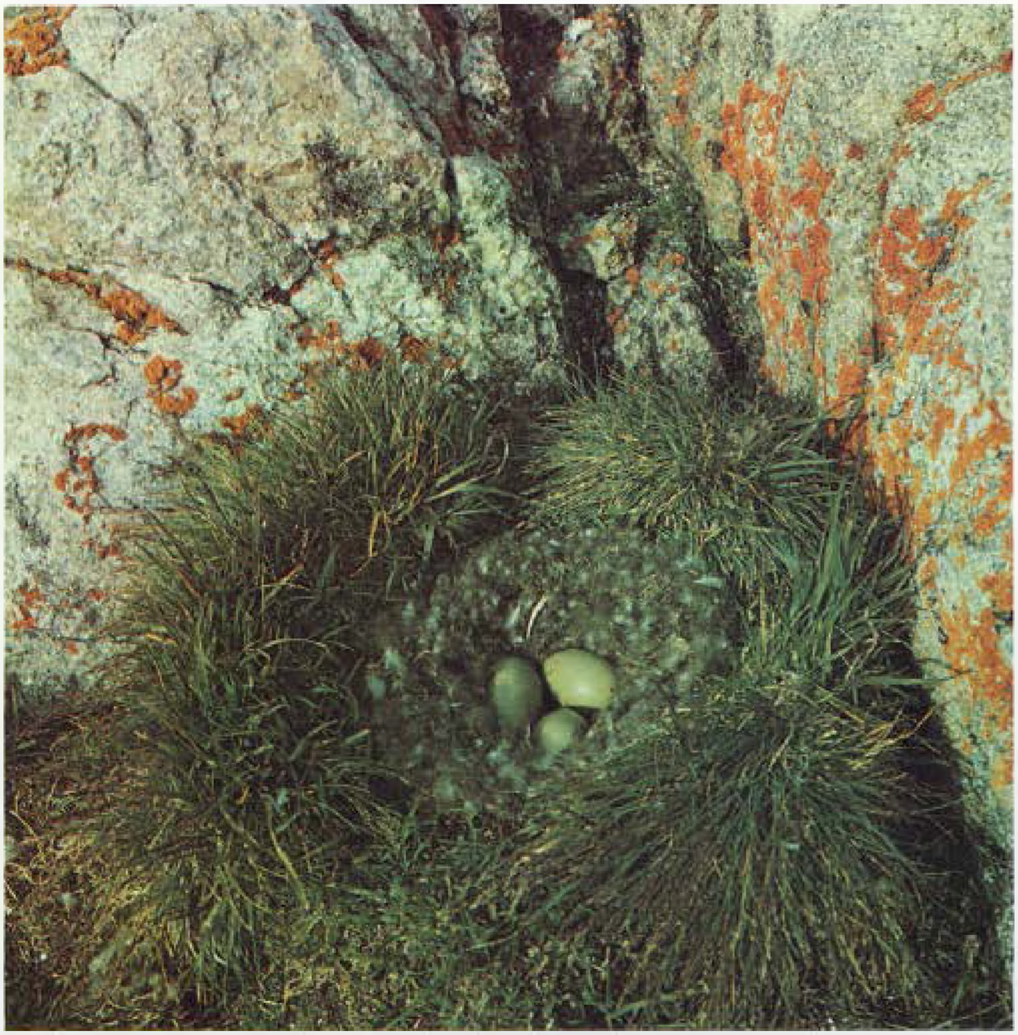
The bladdernose and harbor seal are very rare summer guests.

BIRDS.

Only the most important species are mentioned here.

The little auk *(Plotus alle)* occurs by the millions in the mountains from Cape Atholl and southward to Melville Bay, as well as on the island Kiatak and on the northern coast of Murchison Sound as far north as Etah. It arrives at the end of April and goes into the mountains to breed in May. It lays its eggs under the stones in the scree along the coast and high up in the mountains far inland. It leaves the mountains late in August. Its nourishment consists of plankton *(Calanus)*. It can be found at the beginning of the summer in small flocks everywhere where there is open water. Later in the summer it goes further out to sea. It serves as the chief food for the Arctic fox during the summer. In May and June the Greenlanders catch it in nets and collect its

Stomach content of a bearded seal from Nege. (Top to bottom): Row 1 shows 8 Decapoda, 1 Anonyx nugax, 1 Neohelia maxima, 1 Archeus boffeli, and 1 Rossia. Rows 2, 3, and the left half of Row 4 shows 26 Buccinum sp. The right half of Row 4 and Rows 5 and 6 show 49 shell lids of Buccinum sp. Bottom Row shows some intestinal parasites, parts of 1 Gadus saida, 2 beaks of Rossia, 2 otolith of Gadus saida, and 3 Lycodes sp.



Eider eggs and down.

eggs, in August they catch the young ones before they can fly. *The catching of the young is done by women and children who crawl around amongst the stones and pebbles of the scree and roll the stones down,* thus exposing the young. Life expectancy is approximately 8 years or more. For the most part, the little auk from the Thule district spends the winter in Newfoundland.

The Brünnich's guillemot *(Uria lomvia)* breeds in quantities on the western side of Saunders Island, but also in several other places in the district. There would be a few of them to be found in the crash area during the summer. Their food consists mainly of *Boreogadus saida,* but they also consume larger planktonic *Crustaceans (Themisto, Thysanoessa).* Their life expectancy is up to 16 years or more. The eggs are collected in the bird cliffs, and the birds are shot in numbers both in June and July when they come into the crevices of the sea ice, and during the summer in the bird cliffs, and on the sea south, west and north of Saunders Island. They seemingly spend the winter in central west Greenland and in Newfoundland.

The black guillemot *(Cephus grylle),* can be found during the winter in places with open water owing to currents in and along the ice edge. It breeds in the scree along all of the coasts. Its food consists mostly of *Crustaceans,* especially *Mysis,* but also of smaller fish. It is shot a good deal along the coast, especially in the spring along the crevices in the ice. During the summer it is common along all the coasts around the area of the accident.

The glaucous gull *(Larus hyperboreus)* breeds in many places in the Thule district. It arrives early in the spring, while the sea ice is still there. It has its nests on the mountain ridges on Saunders Island, but also in many other places. It begins to lay its eggs in May. Its food is varied and is searched for everywhere on the ice, along the beach and in the mountains: other birds' eggs and young (especially the little auk), carrions, beach debris, fish, *Crustaceans,* snails, bivalves, berries in the mountains, etc. During the entire summer, it can be seen *searching the beach and taking what it finds.* It is shot a good deal, especially the young, in August and September. It spends the winter along the coast of West Greenland. Its life expectancy is approximately 20 years.

The kittiwake *(Rissa tridactyla)* breeds several places in the mountains of the outer coast. Its most important food is small fish and plankton, which it finds on the surface of the sea. It spends the winter on the Atlantic Ocean, especially off Newfoundland, but it can also roam about. It is shot to some degree during the summer.

The eider *(Somateria mollissima).* Some eiders spend the winter beyond the ice edge, but the majority leaves during the winter and returns in early spring when crevices begin to form in the ice. They can thus be found in crevices and openings in the ice along the coast, especially around certain breeding islands, of which the closest are Eider Islands, Dalrymple Rock and Manson Islands. The eider's food consists mostly of bivalves and snails, which it eats from the lower bottom depths, but it also eats pteropods in great quantities. Some eider hunts are carried out during the summer, but the collecting of eggs and eiderdown is of the *greatest* importance, although this is only allowed on one occasion at each breeding place before 1 July, after which access to the islands is prohibited. The collecting of eiderdown is again carried out at the deserted nests after August 10. *The collection of eiderdown and especially its cleansing is a dust-making process.* The population does the rough work of cleaning themselves, while *the fine cleaning is done at Upernavik.* The eider from Thule spends the winter outside the ice edge between Godhavn and Sukkertoppen.

The king eider *(Somateria spectabilis)* has a similar way of life as the eider, except that it breeds near the inland fresh water lakes. But when not breeding, it also gets its food from the lower sea depths. Eiderdown is not collected from the nest of the king eider.

The long-tailed duck *(Clangula hyemalis).* This bird breeds near the inland lakes, but during the spring and summer it frequents the sea along the coast where its food consists of *Crustaceans,* bivalves, *(Modiolaria, Mya, Macoma, Saxicava)* and snails *(Margarita).* It is rarely shot in the Thule district, although more are shot at its winter residence. It spends the winter for the most part along the coast of West Greenland, but birds from Greenland can also be found in the northern areas of the entire world, including Denmark.

Waders in small numbers frequent the beach where they search for food during their autumn migration in August and September: Turnstone *(Arenaria interpres);* Bairds sandpiper *(Calidris bairdii);* purple sandpiper *(C. maritima);* knot *(C. canutus);* ringed plover *(Charadrius hiaticula);* and the red-necked phalrope *(Phalropus lobatus.)* The waders live on the *amphipods,* snails, bivalves and insects from the beach.

Falcons. Both the gyr-falcon *(Falco rusticolus)* and the peregrine falcon *(Falco peregrinus)* are breeding in a few places in the district. Their food consists of other birds, especially little auk, Brunnich's guillemot, gulls and ptarmigan.

The Ptarmigan *(Lagopus mutus)* breeds in small numbers inland. It feeds on plants, especially willow buds during the winter. It spends the winter in the district.

The raven *(Corvus corax)* is common everywhere both in summer and winter. It is particularly numerous around the dumps at the base. It seeks its food everywhere on the sea ice, along the coasts and on land, and *collects objects and flies around with them* and consumes everything edible: Carrions, birds, eggs, fish, *Crustaceans,* snails, bivalves, berries, fox excrement, etc. Many young birds are shot at the end of the summer, and the raven is often caught in fox traps. It is tasty and eaten with great pleasure.

LAND MAMMALS.

The Arctic fox *(Alopex lagopus)* occurs both as a blue fox and as a white fox. It is common throughout the district, but is particularly numerous in the base areas and in the little auk cliffs around Cape Atholl and southward. During the winter a varying number of white foxes come in from Ellesmere Island. These are larger than the Thule fox. During the summer, the fox lives mostly on little auks *(Plotus alle),* but it also seeks food along the shore, where it eats snails, bivalves, *Crustaceans,* fish, seaweed and dead animals, In the mountains it collects berries: *Vaccinium uliginosum* and *Empetrum nigrum.* During the winter, the fox wanders around a good deal and collects whatever it can find on the ice, and along the tidal cracks of the beach. It feeds on dead birds, berries and plants in the mountains, and at Thule base, particularly on garbage from the dump.

The fox and man: The fox is shot or caught in traps at a rate of 1000-1500 yearly in the entire district. The hunting season is from September to March 31. The fox is taken home, thawed and skinned by the women. The skinning begins at the mouth, and the entire body of the fox is taken out through the animal's mouth. *During the skinning and working of the hide, the women use their lips and teeth to a great extent.* Before World War II, the meat of the fox was always eaten after having been cooked for a very long time. It must be supposed that this still holds true. The inner organs are not eaten. Few foxes live to be more than 2-3 years old.

The polar bear *(Ursus maritimus)* is an occasional guest in the populated Thule district. One to two bears wander through the crash area per year. The polar bear may also be found hibernating in the district, either on the islands or on the mainland. The real bear hunts take place at Melville Bay, Kane Basin or on the sea ice off Ellesmere Island. The most important foodstuff for the polar bear is the ringed seal. Between 20 and 25 bears are shot annually. The meat, except for the liver, is eaten, and the fur is used for trousers. The life expectancy of the polar bear is 30-40 years.

The hare *(Lepus variabilis)* is found on the islands and mainland, especially in the little auk cliffs where there is good grass vegetation. Its most important food is grass, herbs and willow branches. It is shot in small numbers. Its meat, heart, lungs, liver and kidneys are consumed.

The caribou *(Rangifer tarandus)* is not found in the immediate vicinity of the base. A few are to be found in Olriks Fjord.

Bottom sampling is seen on the ice placed on a plastic sheet to avoid contamination (middle left). The snowmobile was used for transportation as well as for hoisting the grab.

The water sampler is hoisted on board AGLANTHA.

A report of the collection of biological and bottom samples immediately following the accident and during the summer expedition surveillance of the shorelines.

ECOLOGICAL SURVEY

F. HERMANN
Hydrographer, Danish Institute for Fisheries and Marine Research
and
CHRISTIAN VIBE
Assistant Professor, Zoological Museum, University of Copenhagen

SAMPLING IMMEDIATELY AFTER THE ACCIDENT

SOON after their arrival at Thule, the Danish Scientific Group realized that the sea ice had been broken through by the disintegration of the bombs and that some of the released plutonium might have ended up in the water and on the bottom of the sea. An examination of water, plankton, bottom material, bottom animals, and marine mammals of the area was therefore considered necessary in order to establish to what extent a danger might be present for the native population through contamination of the various links in the food chain.

As such an examination had been anticipated, a bottom sampler and a water sampler had been brought along from Denmark. For the practical performance of the examination the base made two weasels and their crews available with Capt William McRaney in charge

Date	Station no.	Position	Depth	Thickness of ice	Thickness of snow	Bottom material
7th Feb. 68	1	76°29'2 N-69°11'2 W	11 m	120 cm	0 cm	Gravel + algae
7th Feb. 68	2	76°29'2 N-69°13'9 W	34 m	80 cm	10 cm	Rock + stones
9th Feb. 68	3	76°30'5 N-69°17'8 W	223 m	80 cm	5 cm	Fine clay
9th Feb. 68	4	76°31'2 N-69°18'0 W	233 m	80 cm	12 cm	Fine clay
11th Feb. 68	5	76°32'1 N-69°18'0 W	187 m	80 cm	19 cm	Fine clay
11th Feb. 68	6	76°31'65 N-69°15'0 W	143 m	80 cm	12 cm	Sand and clay

on 7th February and Capt Wallace A. Warren on 9th and 11th February. The Danish leaders of the operations were H. Gjørup, F. Hermann and Christian Vibe.

Examinations were made at six stations on the sea ice. Three stations were placed from the southern side of the fjord and outwards towards the area of impact, the remaining three stations were placed some 100 meters west, north and east of the crash site.

At each station six snow samples were taken on the ice, two water samples close to the bottom, one plankton sample from bottom to surface, and one sample of 1/10 m^2 sea bottom including bivalves, snails, worms, etc. In addition, samples of the bottomside of the sea ice were taken at stations 3 to 6.

The low temperature of the air made the samples freeze immediately, so plankton and bottom samples were taken to the laboratory in a frozen condition in plastic bags. Each bottom and plankton sample was divided into two; one of which was handed over to the American health physicists, and the other still frozen was brought home for analysis at Risö Research Establishment.

In addition to these samples from the area under the ice, samples of the animals of the area: ringed seal, walrus, Arctic fox, and dog, were procured with the assistance of Jens Zinglersen. These samples were flown to Denmark and examined at Risö Research Establishment.

When the winter samples were collected the entire area was covered by ice and snow. Further sampling had to await the disappearance of the sea ice when an entirely new situation would exist.

SUMMER ECOLOGICAL EXPEDITION

In the spring of 1968 the Danish Atomic Energy Commission decided to dispatch the fishery research cutter AGLANTHA as operational vessel for a scientific team, who were to determine the extent of the consequences that the spreading of plutonium might have had for the ecology of Bylot Sound. The tasks of the team were:

The beach on the north side of Wolstenholme Fjord is searched for possibly contaminated debris.

• To collect samples of seawater, bottom material, bottom animals (food elements for walrus and bearded seal), *Crustacea* (food elements for little auks, narwhals and seals), fish (food elements for several sea birds), mussels and other invertebrates from the littoral zone (food elements for arctic fox and eider), sea birds, marine mammals, seaweed, lichen, eiderdown, and dust.

• To investigate the shores of Saunders Island, Wolstenholme Island, the Eiderduck Islands, the Manson Islands, the southern shore of Bylot Sound, and the northern shore of Wolstenholme Fjord.

The samples were collected in three zones. Zone I was bounded by a circle with its center in the point of

impact and a radius of 1 km, Zone 2 consisted of Bylot Sound and Wolstenholme Fjord, Zone 3 (control zone) of the region between Cape Parry and Qanaq.

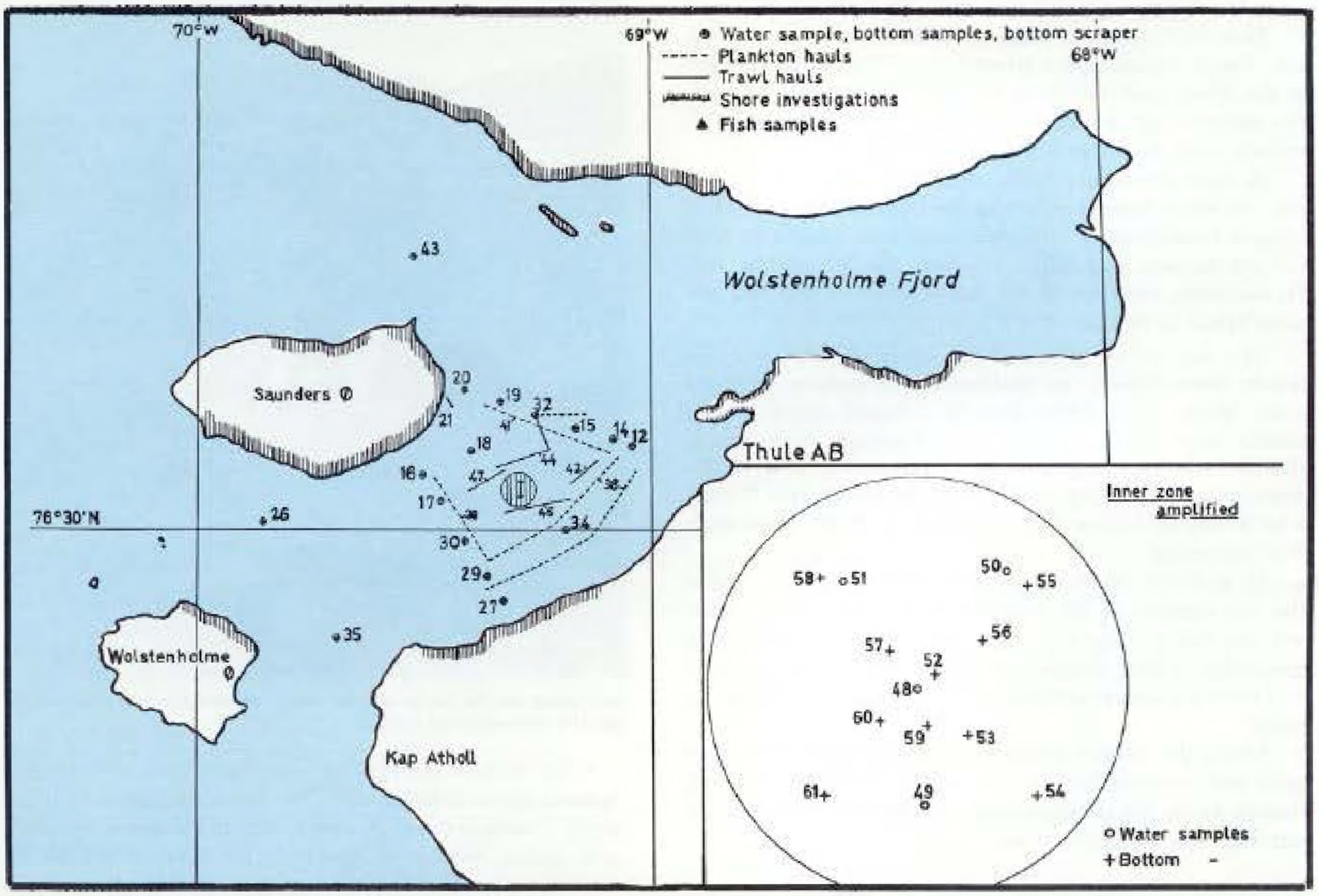
The implements necessary for the investigation were made in the spring at the Risø workshops with valuable assistance from Robert Jensen.

The Danish group consisted of health physicists from the Risø group at Thule (see Mr Walmod-Larsen's article): Messrs G. Jensen and P. Kristiansen, assistants from Risø: Frede Hermann, hydrographer from the Danish Institute for Fisheries and Marine Research; and Jean Just and Christian Vibe, Zoologists from the Zoological Museum of the University of Copenhagen. Professor Jørgen Koch visited the group during the field work at Thule and participated in the investigation for some days.

The Danish ecological group arrived in Thule on 24 July 1968. On the same day W. C. Hanson, Department of Biology, Ecology Section of the Hanford Laboratory, U.S.A., joined the group with the special purpose of collecting lichens on the coasts of Bylot Sound. The fishery research ship AGLANTHA arrived on 1 August, and the scientific equipment arrived on the PERLA DAN on 8 August.

The map below shows the sea stations where samples of water, sea bottom, and animals were collected. These comprised:

- 250 water samples from bottom to surface, collected for hydrographical purposes at 22 stations.
- 4 water samples, each of 100 litres, from Zone 1 (the impact area).
- 14 water samples, each of 50 litres, from Zone 2 (outside the impact area).
- 10 samples of bottom material from Zone 1.
- 10 samples of bottom material with animals, including bivalves, from Zone 1.
- 14 samples of bottom material from Zone 2.
- 25 dredge hauls for bottom animals at 14 stations in Zone 2.
- 6 trawl hauls for *Crustacea* and fish in Zone 2.
- 16 plankton hauls in Zone 2.



Map showing the sea stations where samples of water, sea bottom, and animals were collected.

In addition, the team collected seven seals, six walrus, two eiders, five guillemots in Zone 2 and four in Zone 1, six black guillemots, eiderdown from the Manson Islands and from the Eiderduck Islands, excrements from about 30 eiders on Saunders Island, dust from Saunders Island, Wolstenholme Island and Narssarssuk,

seaweed from Narssarssuk, the north coast of Wolstenholme Fjord, the north coast of the Dundas peninsula, and from Thule (Qanaq), lichen from Narssarssuk, Wolstenholme Island, the southern, eastern and northern shores of Saunders Island, Nunatarssuak, Cape Atholl, the northern shore of Wolstenholme Fjord, Herbert Island, and Inglefield Fjord near Thule (Qanaq). In addition, Mr Hanson collected samples of lichen from a great number of shore stations round the area of impact. Numerous samples of sea and bottom animals were collected for scientific purposes from Bylot Sound, Whale Sound and Murchison Sound.

The surveillance of shorelines was carried out on foot. American helicopters and cars were used for transportation to and from the investigation areas. The map shows the stretches of coast examined for wreckage from the B-52. Nothing was found.

Greenlanders from Maniussak found flat pieces of wood from two huts in the camp by the point of impact on the sea ice, which washed ashore at the northeast point of Saunders Island. A black flag on a short bamboo stick—the same kind as those used to mark the area of impact—was found on the southern side of the island. A few long bamboo poles—used to mark the driving lanes on the ice—were found washed ashore on the south coast of Bylot Sound, on Wolstenholme Island, on Saunders Island, and on the north coast of Wolstenholme Fjord. They were found to be clean from radio activity.

Greenlander equipment found in depots on the shore, driftwood and other flotsam that washed ashore were tested for contamination and found negative.

An exception was the remains of a helicopter crash, several years old, the ashes of which showed some radium activity originating from the luminescent coating of the instrument dials.

The Greenland villages Narssarssuk and Maniussak, as well as the hunting huts on the Manson Islands and Saunders Island, were tested for contamination and found negative. Some urine samples from Greenlanders at Narssarssuk were taken to Risö for testing. These Greenlanders hunted in the vicinity of the impact area.

All collected material was taken to Risö. The zoological and hydrographic samples were forwarded to the Zoological Museum and the Danish Institute for Fisheries and Marine Research.

The ecological group finished its work on 26 August 1968.

The last day at Thule Air Base the members of the ecological group were shown a recording of the bottom survey conducted by Lt Col Marshall E. Neal.

During their stay at the Thule Air Base the Danish scientists received prompt and valuable assistance from the Thule Air Base Commander, Col C. S. Dresser, as well as from all other American personnel at the base, especially the helicopter pilots Maj Frank Schnee, Maj Charles Simmons, Maj Sam Scamardo, and TSgt G. R. Mattews.

The remains of an old helicopter found on the southern shore of Bylot Sound.

The zoological material from the sea bottom and lichens gathered in the summer of 1968.

The purpose of the radio-ecological study was to determine whether plutonium was present in the environment in concentrations which might be harmful to man and animals and to collect information on the radio-ecology of plutonium.

RADIO-ECOLOGICAL INVESTIGATIONS

ASKER AARKROG
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Research Establishment Risö

INTRODUCTION

DURING the first week after the accident, environmental samples of seawater, bottom sediments, and zooplankton were collected from holes drilled through the ice in Bylot Sound (see Christian Vibe's articles titled "Ecological Survey"). Most of these samples showed no or only a small Pu 239 content; however, a few samples showed levels significantly above background. As it was extremely difficult to ensure that the marine samples collected in the early period had not been contaminated by surface snow (which contained Pu 239 in most cases), it was decided to make a more detailed radio-ecological study of the environment in August, when the ice had broken up in Bylot Sound.

The purpose of such a study was to examine whether plutonium was present in the environment in concentrations that might be harmful to man and animals, and to collect information on the radio-ecology of plutonium, which is only imperfectly known.

FALLOUT LEVELS

Since the beginning of nuclear weapon testing, plutonium has been present in nature. The global inventory of Pu 239 in worldwide fallout is at present approximately 0.3 megacuries, or approximately 5 tons. In the temperate zone of the northern hemisphere the accumulated Pu 239 fallout is approximately 1-2 mCi Pu 239/km^2, and in the arctic environment the level is estimated at 0.2-0.4 mCi/km^2. Hence in Bylot Sound (approximately 300 km^2), before the B-52 accident we had approximately 0.1 Ci Pu 239 or 1-2g plutonium from fallout.

EARLIER MEASUREMENT OF PLUTONIUM IN MARINE ENVIRONMENTS

The measurements of plutonium from fallout in marine environments have been few. A 1964 American report (Pillai et al.[1]) found extremely low concentra-

[1]K.C. Pillai, R.C. Smith and T.R. Folsom, Nature 203, 568-571 (1964).

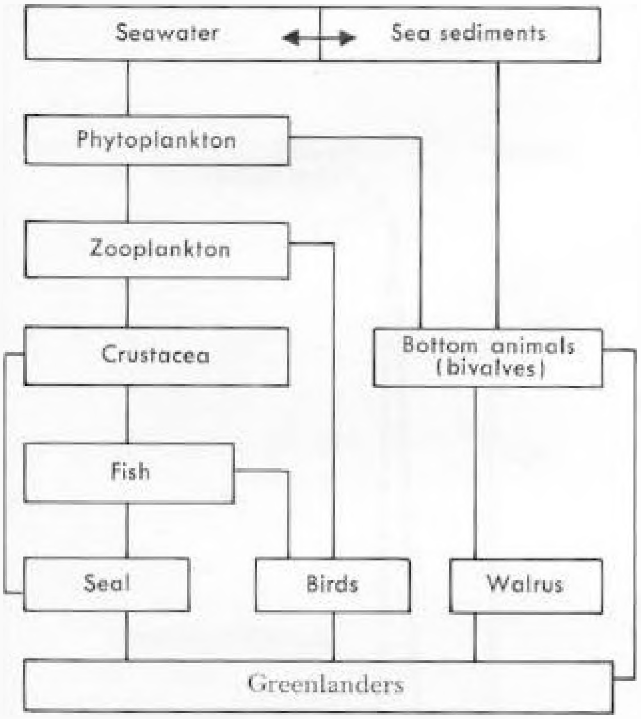

Figure 1 Food chains in an arctic, marine environment.

tions in seawater, of the order of fCi/1 (1 fCi = 10^{-15} curies). Pillai found that especially zooplankton and bivalves concentrated plutonium from the seawater. The activity ratio between 1 kg fresh weight of zooplankton and 1 kg seawater was approximately 2,500, and for bivalves Pillai found a ratio of approximately 250.

FOOD CHAIN

The ultimate goal of a radio-ecological survey is to evaluate whether the radioactive substance under study reaches man in harmful quantities. Figure 1 shows a simplified model of the food chain in an arctic marine environment like the Thule area. The Greenlanders are hunters, not fishermen. The animal most important for their nutrition is the seal; they eat the meat, heart, liver, and kidneys. The Greenlanders also eat walrus, although this animal is normally used for the dogs; from the stomach contents of the walrus they get bivalves. As mentioned by Vibe, birds are hunted during the summertime and eggs are collected in appreciable quantities.

• *Primary Samples.* As will appear from Figure 1, seawater and sea sediments are the first links of the food chain. The levels in these media determine the levels in the remaining part of the food chain. Samples of seawater and sea sediments were hence considered primary samples, and were as far as possible to be collected at all locations. The collection of these samples was carried out with special equipment constructed by the Danish Atomic Energy Commission. The water sampler (Figure 2) had a collection capacity of 100 l of water

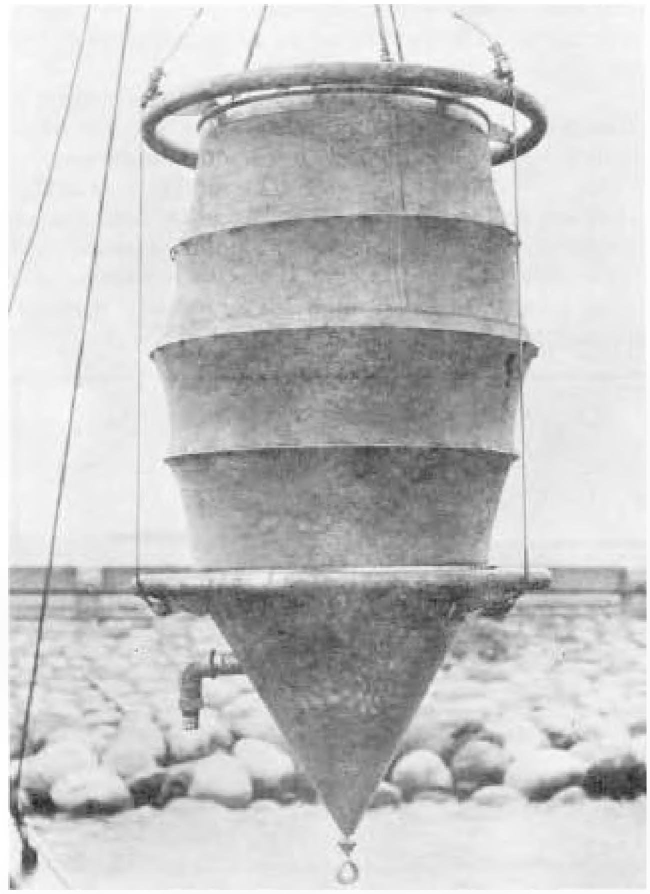

Figure 2 100-litre water sampler.

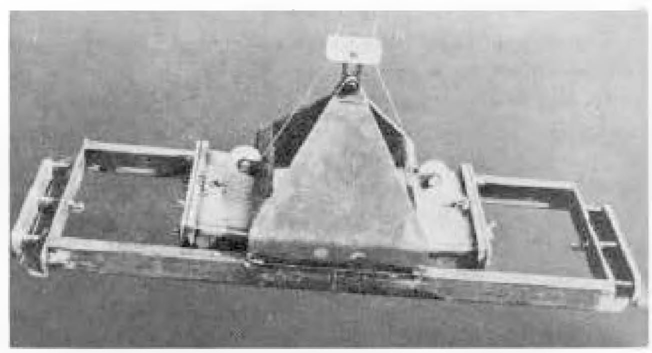

Figure 3 0.1 m^2 sediment sampler.

from any depth from the surface down to the bottom, and the sediment sampler (Figure 3) scraped the uppermost layer of the sea bottom to a depth of 1 cm over an area of 0.1 m^2.

• *Secondary samples.* The secondary samples: with the aid of the ship AGLANTHA, bivalves, zooplankton, crustacea, and fish, were collected by using triangle dredge, plankton net and shrimp trawls.

• *Ternary samples.* The ternary samples: seal,

birds and walrus, were mostly obtained by the Greenlanders, But a few were killed by lucky members of the expedition.

• *Urine samples.* Finally, urine samples were collected from the Greenlanders for the purpose of checking any human body burden of plutonium.

• *The sampling area.* The sampling area(Figure 4) was divided into two zones, I and II. Zone I was a circular area with its center at the point of impact and with a radius of 1 km, and Zone II was the remaining part of the surrounding area in Bylot Sound and Wolstenholme Fjord.

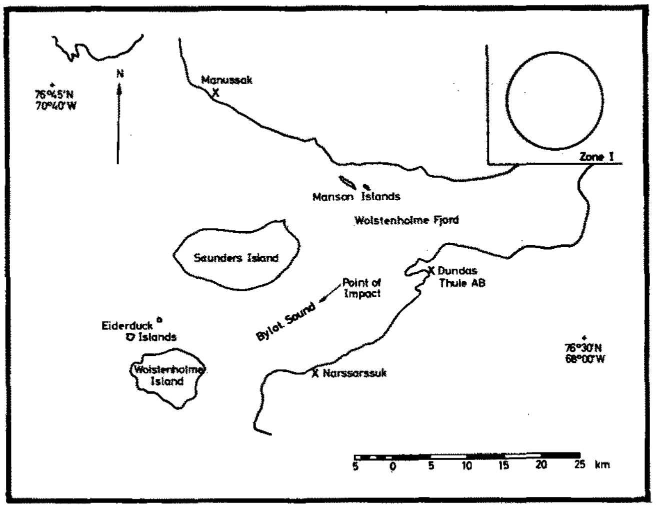

Figure 4 The sampling area at Thule AB, Greenland. Zone I has its centre at the point of impact.

• *The sampling team.* The scientific expedition consisted of one zoologist, one marine biologist, one hydrographer, two physicists, two assistants for the sampling, and an American lichenologist. The sampling began in the last week of July and was finished by the end of August. By then more than 150 samples had been collected for plutonium analysis.

• *Sample treatment.* The samples were kept at -10°C until they could be processed in the laboratory. The solid samples were ashed at 600°C, and after the addition of carriers and spikes, the ash was melted with potassium pyrosulphate to ensure that all plutonium was in a soluble form before the radiochemical analysis, developed especially for this purpose by a combination of an American ion-exchange procedure and a Danish extraction method. After the radiochemical analysis, which could be accomplished within a day for most types of samples, the samples were counted for 3-4000 minutes on silicon-surface-barrier α-counters in connection with a multichannel analyzer. Figure 5 shows a typical spectrum from one of the stronger samples. Seawater samples were processed by a similar method; iron hydroxides were in this case precipitated directly from a 50-litre sample.

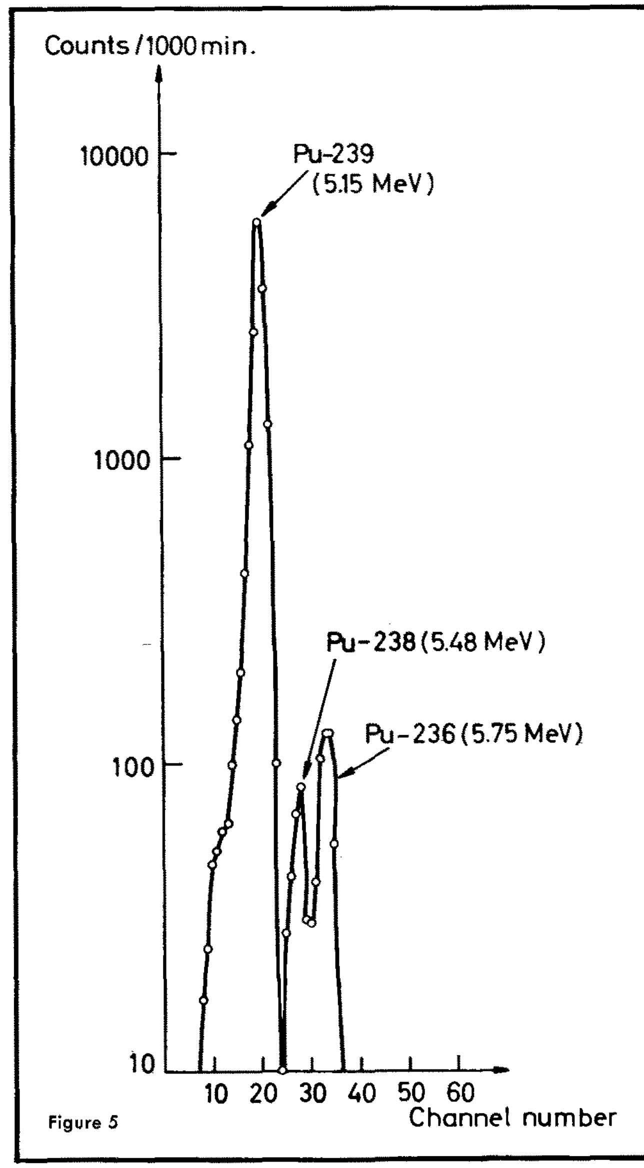

Figure 5

The α-spectrum of a bivalve sample from zone 1. The activity ratio Pu 238/Pu 239=0.02. This ratio was nearly the same in all samples from Thule in which Pu 238 was detectable. (Pu 236 is the spike used for the yield determination.)

RESULTS

• *Sea water.* In Figure 6 the results of the seawater analysis are shown. The maximum for water samples was 76 fCi Pu 239/litre found in a sample collected approximately 5 km west of Dundas Mountain. The median fallout background in seawater from five Greenland locations far away from Thule (Danmarkshavn, Angmagssalik, Prins Christians Sund, Godthåb, and Godhavn) was 4 fCi Pu 239/litre as compared with the median level found at Thule: 5 fCi Pu 239/litre. At Qanaq, approximately 100 km north of Thule, the level was 3 fCi Pu 239/litre. In Zone I the seawater samples were collected both at the surface and at the bottom.

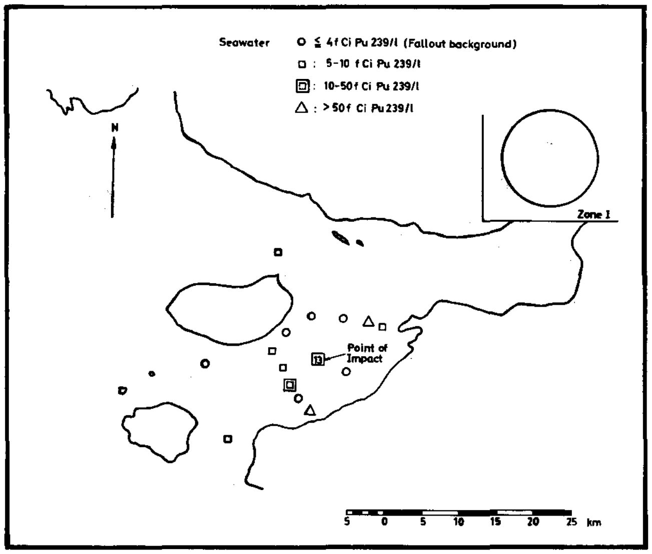

Figure 6 Pu 239 levels in seawater. Thirteen samples were collected in zone I.

From most other locations at Thule they were collected only at the bottom. The samples from Zone I showed that the bottom samples normally had a slightly higher activity than the surface samples. A number of samples were filtered through a 1 μ millipore filter before the analysis, and filtrate and filters were analyzed separately. These analyses gave no indications of significant amounts of particulate ($>$ 1 u) activity in the water samples. However, we do believe that the few samples that showed relatively high levels (10 fCi Pu 239/1) contained particulate activity, probably particles stirred up from the bottom during the sampling.

It is concluded that the accident caused only a slight increase in the Pu 239 concentration of the seawater in Bylot Sound.

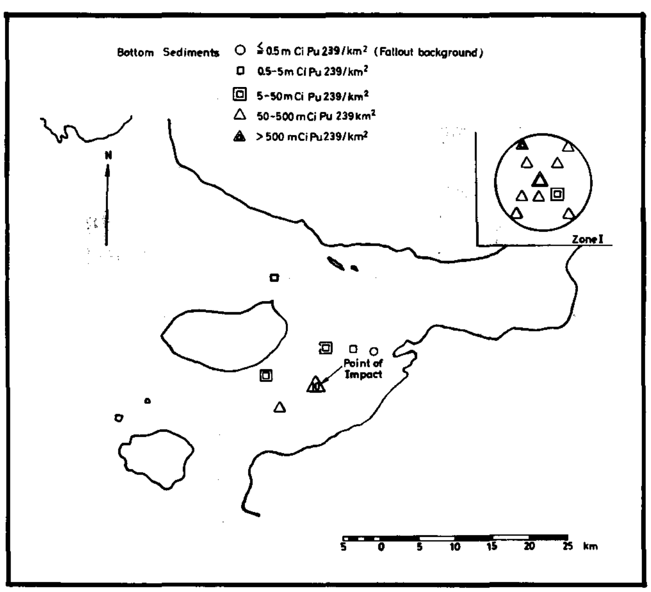

Figure 7 Pu 239 levels in bottom sediments. Ten samples were collected in zone I.

• *Bottom sediments.* The median level of bottom-sediment samples collected in Zone II was 4 mCi Pu 239/km^2, whereas it was 120 mCi Pu 239/km^2 in Zone I. The highest level was found 1 km northwest of the point of impact; at that location 1300 mCi Pu 239/km^2 was found. From the median level the total deposition of Pu 239 in Zone I (3.14 km^2) was estimated at 0.4 Ci. In the remaining part of Bylot Sound (300 km^2.) the Pu 239 level in the bottom sediments was estimated to approximately 1 Ci. These estimates do not include Pu 239 on pieces of debris, which might remain on the sea bottom.

It is concluded that the Pu 239 level in the top layer of bottom sediments in Bylot Sound is approximately 10 times the expected fallout background. In the inner zone around the point of impact the level was more than 100 times as high as the background. This inner zone of high activity might extend as far as a couple of kilometers from the center.

• *Seaweed.* The plutonium level in sea plants (*Fucus* and *Laminaria*) was measured in seven samples collected along the shores of Bylot Sound. The median level was 0.4 pCi Pu 239/g ash (15 pCi Pu 239/kg wet weight) as compared with 0.2 pCi Pu 239/g ash in samples collected in other parts of Greenland (Godthåb, Prins Christians Sund, Danmarkshavn). A sample from Qanaq contained 0.3 pCi Pu 239/g ash.

It is concluded that sea plants showed levels of Pu 239 hardly significantly above fallout background.

• *Plankton.* Mixed samples of zooplankton were collected in the surface water layers southwest, northeast, and southeast of Zone I. Furthermore *Gammarus* were collected along the shore at Manussak and north of Dundas Mountain. The median level of the zooplankton was 3 pCi Pu 239/kg fresh weight. In *Gammarus* the mean level was 30 pCi Pu 239/kg. If the ratio between the plutonium levels in zooplankton and seawater is 2,500 (cf. above), the estimated plutonium level in zooplankton (incl. *Gammarus*) is 2,500 • 0.005 pCi/kg ~10 pCi/kg.

It is concluded that the plutonium level in zooplankton (incl. *Gammarus*) was hardly significantly different from the fallout background.

• *Crustacea.* Eight samples of *Crustacea* caught during trawling on the outskirts of Zone I were analyzed. Some samples were divided into flesh and shell. The median level of the total animal samples was 1,900 pCi Pu 239/kg fresh weight. The median levels of the flesh and the shell samples were 95 and 330 pCi Pu 239/kg respectively. The maximum level for *Crustacea* samples was 12,000 pCi Pu 239/kg total animal. Shells normally contained more Pu 239 than did flesh. As these *Crustacea* are bottom animals, it is believed that most of their plutonium content was particles incorporated from the bottom sediments. Samples of *Crustacea* from southwest Greenland contained 3 pCi Pu 239/kg, and samples

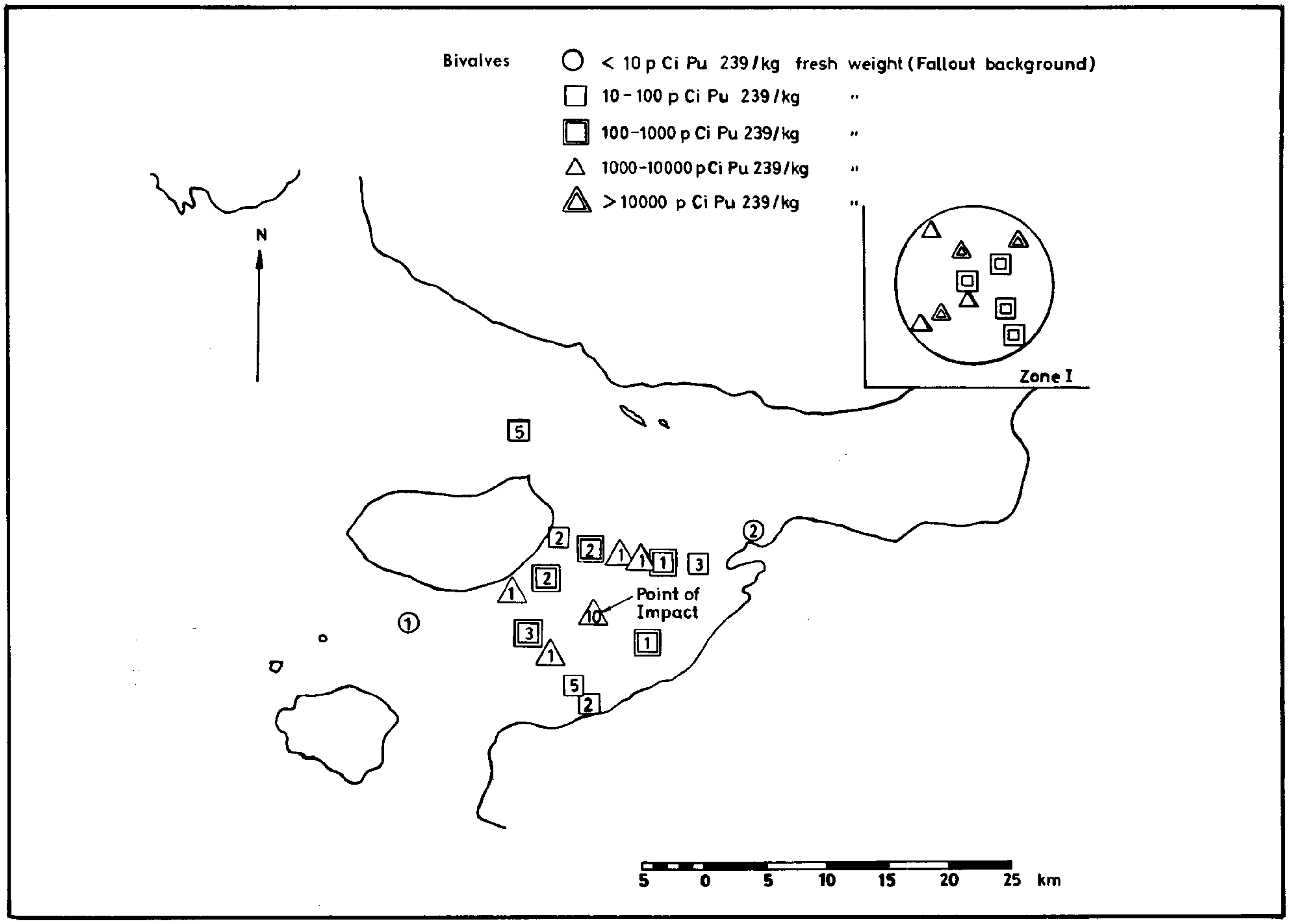

Figure 8 Pu 239 levels in bivalves. The numbers refer to the number of samples analyzed from each location.

from Danish inner waters contained 2 pCi Pu 239/kg.

It is concluded that *Crustacea* from Thule contained certain amounts of Pu 239 from the accident, the median level being nearly 1,000 times the fallout background.

• *Bivalves.* Figure 8 shows the level of Pu 239 in bivalves. The median level of all samples from Zone II was 64 pCi Pu 239/kg. In Zone I it was 8,000 pCi Pu 239/kg. The maximum level was 76,000 pCi Pu 239/kg; the sample concerned was collected in Zone I, a few hundred meters north of the point of impact. The fallout background in bivalves was estimated to be approximately 5 pCi Pu 239/kg on the basis of measurements of bivalves from Danish waters. Figure 8 shows that nearly all samples from Thule were above this fallout background. Bivalves thus seem to be very sensitive organisms for the detection of plutonium in marine environments. Five different species of bivalves were investigated; it was, however, not possible to see any significant difference between the plutonium levels in the different species. From replicate analysis it was evident that the plutonium activity was very inhomogeneously distributed within a sample. This was undoubtedly due to the fact that most of the plutonium in the mussels was in particulate form.

It is concluded that bivalves contained plutonium levels significantly higher than background and that the highest concentrations (more than 1,000 times the fallout background) were to be found near the point of impact. Plutonium could, however, be detected in levels significantly above background even as far away as 20 km northwest of the crash area.

• *Bottom animals.* From Zone I a few samples of worms, starfish and sunstars were analyzed. A mixed sample of worms from nine stations in Zone I contained 30,000 pCi Pu 239/kg, and starfish and sunstars contained between 190 and 1,100 pCi Pu 239/kg fresh weight.

It is concluded that not only bivalves, but also other bottom animals, concentrate Pu 239 from the environment and that significant amounts were present especially in the samples collected near the point of impact.

• *Fish.* Sea scorpions were found at the shal-

low waters along the southeast coast of Saunders Island. Two samples were analyzed. The plutonium content of the first sample was hardly significantly above the background, the other sample contained 14 pCi Pu 239/kg. The polar cod is the most common fish in the district. Three samples of this species were analyzed and showed levels from 19 to 230 pCi Pu 239/kg. A Greenland halibut caught just north of Zone I contained 470 pCi Pu 239/kg. This was the maximum level found in any fish sample. The medium level of all fish samples (10) was 37 pCi Pu 239/kg.

It is concluded that especially fish living near the sea bottom, as the Greenland halibut, contained Pu levels significantly above fallout background. However, the concentrations were lower in fish than in bivalves and *Crustacea.*

• *Sea birds.* Five samples of intestinal contents of eider, black guillemots and Brünnicks guillemots were analyzed. The median level was 3.5 pCi Pu 239/kg. Eiderdown collected on the Manson Islands and the Eiderduck Islands contained 130 pCi Pu 239/kg down and dust (adhering to the down).

It was concluded that the sea birds contained plutonium levels which were hardly above the fallout background. The plutonium levels in their intestinal contents were nearly the same as in zooplankton, which is a main constituent of their diet. The down, or rather the dust in the down, from the Eiderduck, however, contained significant levels of plutonium.

• *Seals.* Five samples of intestinal contents of seals killed in Bylot Sound and Wolstenholme Fjord were analyzed. The medium level was 1 pCi/kg fresh weight. The maximum level was 4 pCi/kg found in the stomach contents of a ringed seal shot by the expedition just north of Narssarssuk.

It was concluded that seals contained very low levels of plutonium, and that the levels were hardly significantly different from the fallout background.

• *Walrus.* Intestinal and stomach contents of five walruses killed in late spring west of Saunders Island were analyzed. The median level was 1.3 pCi Pu 239/kg and the maximum was 1.8 pCi Pu 239/kg. It was concluded that walrus did not contain Pu 239 levels significantly above background. On the other hand, this was not unexpected, as the walrus were killed before the ice melted in Bylot Sound.

• *Human urine.* Samples of urine from the Greenlanders at Narssarssuk were collected three times: just after the accident, in September 1968, and in February 1969. A few of the samples from the first two collections showed traces of plutonium 239; however, the possibility that these samples had been contaminated during the sampling could not be excluded. Hence a new set of samples was collected in February 1969, and none of these samples showed any traces of Pu 239.

It was concluded that it was unlikely that any Greenlander in the Thule district had been exposed to significant internal levels of plutonium as a result of the accident.

• *Hazard evaluation.* The International Commission on Radiological Protection (ICRP) have not given maximum permissible concentrations (MPC) for marine samples. If food habits and concentration factors in the food chains are known, it is, however, possible to estimate an equivalent to the permissible levels in such samples. In this case, probably the bivalves were the critical sampling object. From the ICRP's recommendations for drinking water it is calculated that the maximum permissible daily intake of Pu 239 with the diet is 0.1 μCi. If, for instance, a Greenlander eats 100 g bivalves daily, which undoubtedly is an upper estimate of his consumption, the MPC in bivalves becomes 1 μCi Pu/kg. Even the strongest sample of bivalves contained only one tenth of this pessimistically estimated MPC value.

• *Eiderdown.* Eiderdown collected during the summer is cleaned of dust by the Greenlanders. This cleaning might be a matter for concern as an inhalation hazard if the down and dust contained appreciable amounts of plutonium. From the ICRP's recommendations, the daily permissible intake of insoluble Pu 239 into the lungs is calculated at 200 pCi, i.e., the permissible annual intake would be 73,000 pCi. The concentration of Pu 239 in eiderdown was 130 pCi Pu 239/kg; it is thus extremely unlikely that any Greenlander occupied with the cleaning of down might reach the permissible intake of Pu 239 into the lungs.

CONCLUSION

The radio-ecological investigation showed that the plutonium levels in the collected samples in no instances were such that they can be considered harmful to man or to higher animals in the Thule district or in any other part of Greenland. Nonetheless, the B-52 accident in Bylot Sound at Thule in January 1968 measurably raised the plutonium level in the marine environment as far out as approximately 20 kilometers from the point of impact. The highest concentrations were found in bottom sediment, bivalves and *Crustacea*. The higher animals such as birds, seals, and walrus showed plutonium levels hardly significantly different from the fallout background. Plutonium was not, with certainty, detected in urine from Greenlanders.

ACKNOWLEDGEMENTS

These investigations would have been impossible without the skillful assistance of Lars Bøtter-Jensen, Marianne Christensen, Johs. Jensen, A.P.K. Kristiansen, Birgitte Ladefoged, Jørgen Lippert, Anna Holm Pedersen, Jørn Roed, Else Sørensen, all staff members of the Health Physics Department, and Erik Kjær Markussen, J. Møller Andersen, of the Danish Defense Research Board.

The urine samples were analyzed by Heinz Hansen and Vibeke Jørgensen, The Medical Laboratory of the Danish Atomic Energy Commission.

Danish health physics activities at Thule during the clean-up period.

DANISH HEALTH PHYSICISTS' ACTIVITIES

OLE WALMOD-LARSEN et al*
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Danish workers filling the many rows of 25,000-gallon tanks with contaminated snow and ice.

ABOUT 10 February, Henry L. Gjørup realized that an optimistic conclusion—that very little or no contamination would be found outside the crash area—would in all probability be drawn from the efforts of "Operation Frying Pan." Consequently, he set off for Copenhagen on 14 February in order to take part in the joint U.S.-Danish meeting on 15 February; and to participate in the management of further investigations in Denmark.

Some days after his departure, the "Operation Frying Pan" team concluded that the environmental hazards from Pu 239 outside the crash area were in fact comparable to the accumulated fallout from weapons testing. The team cabled this conclusion to Copenhagen.

On the basis of the team's favorable report it was decided to scale-down the Danish scientific efforts in Thule.

In accordance with the conclusions reached at the February meeting in Copenhagen, namely, to remove as much of the contaminated snow as possible for the sake of good housekeeping, a decision was made to continue the on-scene U.S.-Danish cooperation, mainly on the health physics aspects of the operations to come. This was natural on the part of the Danes, who wanted to ensure that no Danish citizen would be exposed to any hazards in connection with the removal of the contaminated material from Danish territory.

More than a thousand persons assigned to Thule Air Base work for the Danish Construction Corporation (DCC), which with a Danish staff carries out all the civil operations of the base. It was natural, therefore, that from the very start the DCC staff took part in the Crested Ice Operations.

One of the problems facing the Danish health physicist left on his own at the scene after the departure of the Frying Pan Team, was the layman's fear of the unknown: the fear of radiation, of contamination, of atomic weapons, and fear of all the new, unusual phenomena suddenly disturbing the quiet Arctic area at Thule.

Each time Danish participation in the operations escalated, further groups of staff had to be put into the picture, briefed on safety precautions, and made to realize that these precautions were for their own good.

Several briefings were arranged in close cooperation with the DCC safety officer, E. Stubbe Teglbjerg, in order to get things going. Before the removal operations started the DCC key personnel were informed in detail about the radiation-protection measures

*Asker Aarkrog, Lars Botter-Jensen, Poul Christensen, Henry L. Gjørup, Jørgen Lippert, Jorn Roed and Arne Sørensen, Health Physics Department and Leif Løvborg, Electronics Department.

laid down in the U.S.-Danish agreement in the Health Physics Program for Snow Removal Operation.

Another briefing was held a few days later in a heated bus, parked at the work site of the Danish workers who were filling the many rows of 25,000-gallon tanks with the contaminated snow coming in from "Camp Hunziker." This briefing gave rise to one of the more diverting events of the Crested Ice Operations. Contrary to the plans laid down by DCC, the briefing caused a delay of slightly more than one hour because of many questions from the workers. This was a highly undesirable delay considering the fine weather and good operational conditions. When the delay became known the smell of brimstone emanating from the SAC headquarters was detectable several miles off until the reasons for the delay were made clear to General Hunziker, who wanted to speed up the clean-up operations. This speedup was necessary due to the shortage of time and the many unknown factors such as weather conditions and the vulnerability of the vast machinery put into action.

The original idea was that the entire removal operation should be carried out by U.S. personnel, if possible. When Danish assistance was required it was to be for work only in noncontaminated areas, or for work on items proved to be free of contamination.

When the heavy, snow-filled containers were emptied into the tanks, minor spills were unavoidable. Even though these spills were collected immediately with shovels and brooms, there was a risk that contamination might spread throughout the base. The original U.S.-Danish agreement was therefore modified to the effect that the tank-filling area was declared a contamination area with corresponding regulations concerning clothing, transportation and decontamination. No contaminated Dane would be allowed to cross the "hot line" in the decontamination building. Nasal swabs were to be taken, records to be kept, and bioassays carried out as deemed necessary by the health physicists.

At the next briefing for the filling teams, numerous questions were raised as to the reasons for these precautions.

One of the most significant problems only appeared after more than a 1½-hour discussion—the problem was fear of sterility and impotence. When it was explained that these fears were groundless, no further questions were asked!

Another briefing was given to the Danish mechanics working at the Base Motor Pool. The strain on facilities for repair and maintenance of vehicles and machinery operating at the crash site and in the tank area gave rise to a minor spread of contamination originating from the engines, where contaminated snow particles stuck on the warm, oily surfaces and finally melted.

This led to the establishment, within a few hours, of an additional vehicle decontamination facility, and to the enforcement of minor restrictions at the Base Motor Pool which had to be explained to the staff.

Close and frequent contact with union stewards proved useful in ensuring maintenance of good relations with the workers, and also in explaining that the results of nasal swabs and urine samples were found to be negative. This proved that the precautions were entirely adequate and that no Dane had been exposed to any hazards during his work in contaminated areas.

By the middle of April the 140 vehicles and machines were cleared of contamination (except one belt loader which was painted and stored for disposal), and the various areas and buildings used for that purpose at the base were cleaned up.

In April, the crash site was fenced in and marked, and the hunting restrictions were modified, giving Greenlanders access to the rest of the Bylot Sound. After this period the Danish health physics activities in the spring decreased to some visits of a few days' duration.

Later on, when the bay and the harbor were reopened, Danish health physicists were again permanently stationed at Thule until the USS MARINE FIDDLER sailed into international waters carrying on board the last Crested Ice tanks.

The new stevedoring crew coming in from Copenhagen was given a safety briefing. Here, as in the earlier briefings, it proved valuable that qualified persons from an independent authority were present.

Transportation between Thule, in the Polar Region, and Copenhagen, in Denmark, is very infrequent. A regular Scandinavian Airlines (SAS) flight is scheduled for every second Wednesday, and every second Monday an SAS freighter lands at Thule Air Base. Because the flight crews have to return within the same working day, (the flight time being more than 10 hours) the planes must be airborne again in less than 2 hours, which gave little time for briefing and introductions between the incoming and outgoing scientists who took turns at discharging the responsibility for safeguarding the health of the Danes involved in the operation. Nonetheless the team managed to uphold the necessary continuity in this service.

During the entire operation the Danish health physicists had unrestricted access to all data on the measurements made on site and later in the U.S., on bioassays and on all nasal swabs taken. All the measurements proved that during the whole operation no Dane had been exposed to any radiation hazards.

All the items to be transported were cleared in excellent cooperation between U.S. and Danish health physicists. After a thorough survey of the tank farm, the last contamination area at the Thule Air Base, a U.S.-Danish "Final Health Physics Report on Project Crested Ice" drew the conclusion that all areas concerned could be given free with the classification: NDA—No Detectable Activity.

ICE OPERATIONS

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PROJECT Crested Ice was an example of man's ability to use one of nature's materials to advantage. The material in this case was sea ice. Sea ice, when used as foundation or construction material, has stress or safety limits like any other material. It is necessary to understand these limits—to ignore them could result in the loss of life and equipment.

The first trips from Thule to the Broken Arrow site were made by helicopter and dogsled, thus limiting the number of personnel and the amount of equipment which could be transported to the site. It was therefore obvious that surface transportation, other than dogsled, would be necessary for a successful and speedy recovery mission.

The original ice thickness measured 39" near shore and from 23" to 24" at the site, later named Camp Hunziker. The measurements were taken in the center of the newly plowed road that ran from Delong Pier to Camp Hunziker. Variation in ice thickness is normal for a bay or harbor similar to North Star Bay, for the area near shore freezes first and therefore has a greater ice thickness.

The quality of the ice and its measured thickness indicated that the ice could safely carry distributed loads up to 50,000 lbs. It was decided that future transportation to and from Camp Hunziker would be by automotive equipment.

The original road, called Road No. 1, did not run on a straight line from shore to Camp Hunziker. It crossed several large snowdrift areas which were not desirable because of the difficulty of removing the snow after each windstorm. The road was narrow in places because it became impossible to remove the large snowbanks.

In any operation requiring an ice road, it is advisable to have an alternate road. With two roads, the chance of over-fatigue of the ice is limited. This, plus the difficulties encountered with Road No. 1, justified the construction of a second road.

Road No. 2 was laid out on a straight line from shore to Camp Hunziker. It was also laid out so that the snowdrift problem would be at a minimum. It was decided to close Road No. 1 and lay out a new road parallel to Road No. 2.

The two roads were crossed by a number of tidal and thermal cracks. Tidal cracks are produced when the tide lifts and breaks the ice. These cracks usually refreeze and fill with snow. They normally present no danger once the entire bay is frozen over. Thermal cracks are produced when the ice surface is subjected to extremely low temperatures and then stressed by a load. These cracks look dangerous because they can open more than several inches. They rarely penetrate the total ice thickness and again are not dangerous if care is taken.

Two main roads leading to Camp Hunziker.

Crack in the ice.

Each day, notations were made of the location of each crack in the road, measurements were made of these cracks as well as of the ice thickness of the roads. This was a safety measure so that any unusual situation could be monitored before there was any chance of danger. Many 3-inch diameter ice cores were taken in the area. The cores were taken from the clean, black, and impact ice zones. The ice in the clean and black areas was identical to undisturbed normal sea ice.

The ice thickness at the camp and parking area varied from 23" to 24". The camp site consisted of a number of plywood buildings placed close together. They presented no problem as far as critical loads on the ice were concerned, but would have presented a

serious snowdrift problem. For this reason, they were repositioned at least 50 feet apart.

Snow is usually a problem when operating on sea ice. Many man-hours of work and "wear and tear" on heavy equipment can be saved if buildings and roads are aligned to take into account the primary problem of excessive snowdrifting. Large piles of snow can be dangerous—their weight can cause the ice to fail. This was almost the case at Camp Hunziker.

A large building, 92 x 18 feet, was assembled as the main building of Camp Hunziker. It was placed approximately 500 feet from the other buildings and a large parking area was laid out a safe distance (500 feet) from the building. During the evening, a front loader operator removed the snow from the parking area and placed it in a large mound close to the building. Being newly assigned, he had not been told of the dangers in placing such a large load near a building. This oversight placed the personnel and contents, as well as the building itself, in great danger. General Hunziker, first to arrive on the scene the following morning, recognized the hazard and took immediate action to have the snow removed. This incident illustrates one factor which must be considered when operating on sea ice.

Project Crested Ice will long be remembered for many reasons, one of which is highly creditable—that of being one of the most efficient operations ever conducted on sea ice. The ice thickness was marginal from the beginning of the operation, yet there were no accidents due to ice failure. This was attributed to rigid adherence to the necessary discipline. A memo titled "Ice Operations" describing the safe procedures for operating on the existing ice of North Star Bay became everyone's way of life and the conformance to its instructions resulted in an accident-free operation. The memorandum follows:

(Editor's Note; The following procedures were based on the climate and ice conditions at that time and place, and are not recommended for use under other conditions.)

* * * * * * * *

ICE OPERATIONS

OPERATING ON AN ICE SHEET SUCH AS THE ICE IN NORTH STAR BAY CAN BE DANGEROUS IF ONE IGNORES THE GROUND RULES AND INSTRUCTIONS ISSUED BY THE COMMANDER. ONE CANNOT AFFORD TO BECOME CARELESS WHILE OPERATING ON AN ICE SHEET. THE FOLLOWING INSTRUCTION SHOULD BE USED AT ALL TIMES.

1. *Driving on ice road:* The vehicles should be spaced 200 feet apart at all times. If a vehicle is stopped it is permissible to pass but never faster than posted speeds. The road is safety inspected each day for cracks and faults. After a phase, no one is authorized to drive on either of the two roads until they have been inspected by the ice inspection team.

2. *Parking of vehicles:* There are parking signs at the site area which specify the safe parking distance between vehicles. These distances must be maintained.

3. *Foreign material:* It is very important that nothing "dark" be thrown or discarded on the clean ice surface. This includes items such as cigarettes, candy or gum wrappers, waste oil, urine, and wood. Once the sun appears these dark objects will absorb the sunlight at a faster rate than the ice will, therefore causing melting. Once melting begins, a hole or crater will form. These openings can become large enough to lose a large trailer in. It is therefore important to begin "police" practices now. (The clean police habits begun now will insure your safety in a few weeks.)

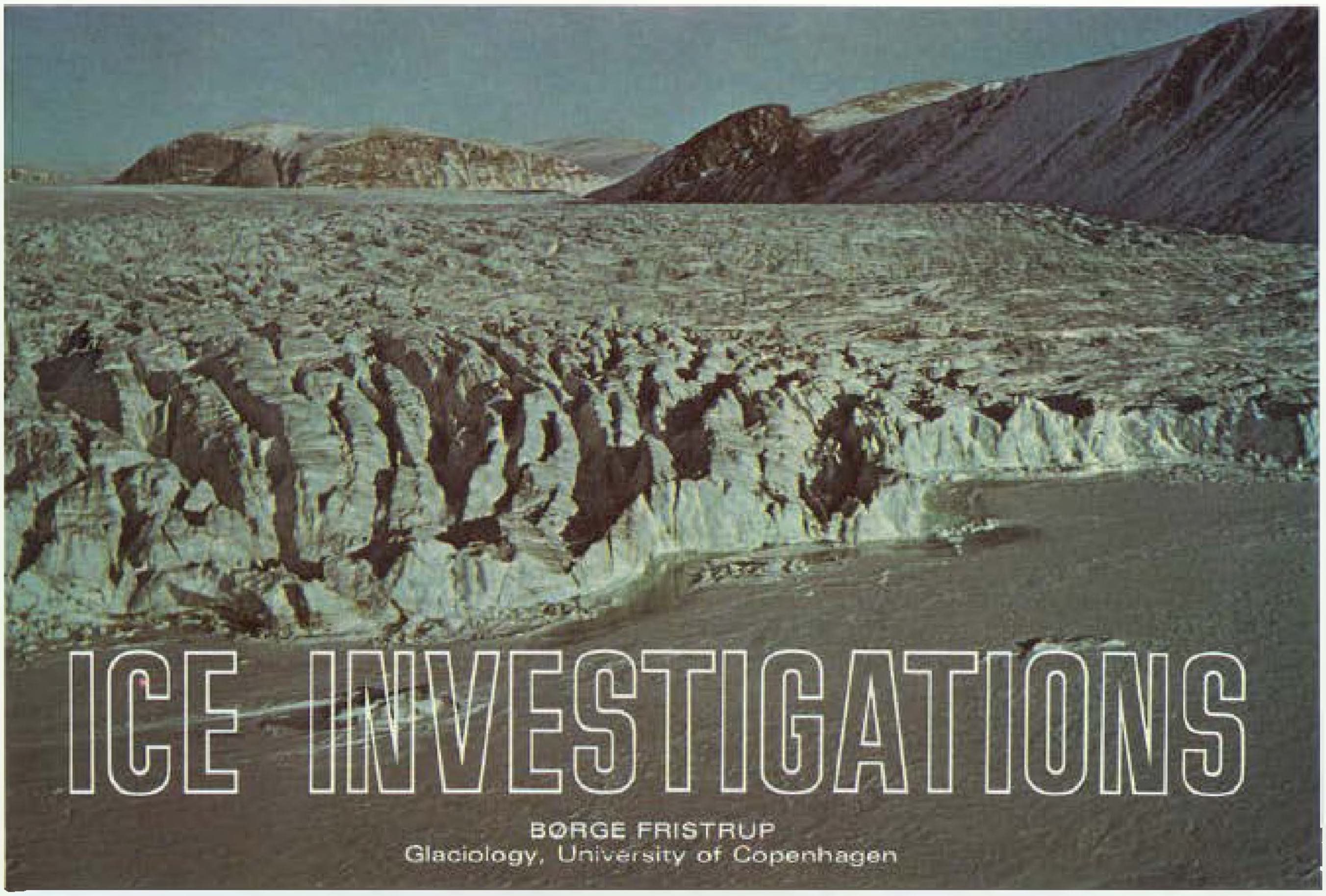
4. *Cracks:* The existing linear cracks in the roads are caused by thermal expansion. There is no danger associated with them. A failure crack will be a circular crack which will form around the load. Considerable deflection will occur before failure of the ice. If you are in a vehicle or building and a circular crack forms, leave the immediate area of the load. Don't panic but leave the building or vehicle quickly and get 50 feet away. If a "lead" opens (a large crack caused by ice movement) don't panic, but return over the road you have traveled until you can report the "lead" by the best available means. You can then return to base via the other road if possible. Should both roads be cut off by a "lead" you will be picked up by a helicopter pending closure of the opening by natural freezing action.

5. *Driving safety:* Always wear your arctic gear while traveling the two highways. Don't park near vehicles, buildings, or heavy objects on ice. (Park 200 feet apart.) Drive carefully and steadily. The ice will normally afford good traction. Observe the road ahead carefully for unusual cracks or snowdrifts. If any are suspected stay clear at least 50 feet. Report any potential problem areas to the Air Police as soon as possible.

* * * * * * * *

Project Crested Ice, as well as previous projects involving ice operations, demonstrated the importance of having previous experience and knowledge of the safety of using ice as a load-bearing material. For this reason, the U.S. Army Terrestrial Sciences Center was requested to conduct the ice measurements and to advise on the overall ice operations.

(Editor's Note: For the information of Air Force officers and civilians who are scheduled for cold regions duty, there is a USAF Civil Engineering sponsored course at the U.S. Army Terrestrial Sciences Center. This course, a 1-week segment of a Cold Regions Engineering Course, discusses the landing of aircraft on ice and approaches, to dealing with engineering problems relating to occupation of, and operations within, the cold regions.)



ICE INVESTIGATIONS

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INTRODUCTION

ON Sunday, 28 January, the Danish Atomic Energy Commission asked me to join the Danish Scientific Group at Thule Air Base. I left on Monday, 29 January, together with Dr P.M. Hansen, marine biologist, Dr C. Vibe, zoologist, and Dr F. Hermann, hydrographist. Weather conditions at Thule Air Base were poor, and just before we reached our destination the airport was closed because of a blizzard and we had to land at Søndre Strømfjord, an alternate airfield. From there the airplane returned to Copenhagen, and an American airplane took us to Thule Air Base on Tuesday, 30 January.

Although we represented different sciences, the members of our party had all worked in Greenland for several years and most of us had a thorough knowledge of the area around Thule.

During the days that followed we made observations in the crash area, and took part in discussions concerning what measures ought to be taken to protect the population.

NORMAL ICE CONDITIONS IN THE AREA

In Bylot Sound, where the accident happened, the ice cover is normally not very thick and rarely exceeds a depth of 1 meter (39 inches), whereas much thicker ice can be found in North Star Bay and Wolstenholme Fjord.

Ice floe.

In the Thule area the formation of fjord ice usually begins at the end of September or the beginning of October. This early ice is often broken up by gales. Really solid ice is not formed until the end of the year. As the winter progresses, the ice gradually becomes thicker.

The rate of growth depends to a great extent on the temperature of the air and the snow covering. A thick layer of snow serves as insulation and the ice will grow slowly, whereas no snow or only a thin covering produces a faster rate of growth. At the beginning of May the ice will crack under the spring sun, and in the course of a few weeks pools of meltwater will gradually form on the surface of the ice. The melting begins and is most intensive in those places where the snow or ice has been soiled by sand or other material which has blown out from the shore. This is because the dark material absorbs the heat.

With increasing air temperature the ice cracks more and more, the pools of meltwater grow in size, and lanes of open water may be seen. The breaking up of the winter ice into drifting floes normally takes from 2 to 3 weeks. As the ice floes drift back and forth with the tides, they gradually tear apart, diminish and melt away. Towards the end of summer, only drifting icebergs are seen in the Thule district. They originate from the calving glaciers, particularly from Moltke Gletscher at the head of Wolstenholme Fjord and from Indlandsisen at the head of Inglefield Bredning.

When the ice in Bylot Sound has broken up, the current and the wind carry it out in Baffin Bay either north or south of Saunders Island, depending on the prevailing weather conditions. If the weather is relatively calm, the ice will usually go out south of Saunders Island, whereas a strong wind from the sea—the normal wind direction in this area—will carry the ice along the coast of Steensby Land and westward. The current may carry the drifting floes close inshore where they may be beached, but there are no particular places in this area where the ice is prone to pack.

ICE CONDITIONS IN THE WINTER OF 1967-68

A map showing the normal ice conditions in the Thule district is shown in Figure 1. In the autumn of

Figure 1. Ice conditions north of Baffins Bay. (Old Map)

Usually unbroken winter ice from October-November to June-July.

Extreme limit of winter ice, often broken during November-February, but usually unbroken from March to the middle of May.

Occasional drift ice, formed by broken land ice, moving southwards.

Banks with grounded icebergs.

Open water owing to currents early in spring, also often at new and full moon throughout the winter.

Ice floe from the crushed spots.

1967, the first freezing up was observed early in September, but a spell of mild weather caused the ice to break up again so that the genuine winter ice was not formed until the middle of October. During November there was a lot of snowfall, so it must be presumed that the winter ice was relatively thin and had not reached its maximum depth when the accident happened. The measurements taken during our investigations showed that the ice was still growing and that it must have been approximately 70 cm (27 inches) thick at the time of the accident.

OBSERVATIONS IN THE CRASH AREA

Observations at the point of impact of the B-52 showed that the sea ice had been broken up. Ice floes of from 2 to 5 meters (79 to 197 inches) in diameter had been tilted upwards. One ice floe had even been pushed right out of the water onto the surrounding ice, and in several places it was possible to see the underside of the floes. Between the floes, in many places one could see a mixture of crushed ice and new ice covered by a

thin layer of snow. A few floes had not capsized but had been lifted up and lay higher than the surrounding ice, as can be observed when the sea ice is no longer coherent but is floating freely as floes in a lane. Pieces of ice were scattered around the point of impact, and it appeared from the texture of the snow that around the crushed ice there had been a zone where the snow had been drenched by sea spray or by a wave breaking in over the ice. The picture of the crushed ice and the piled up floes leaves no doubt that the ice had been broken and that at some moment there had been open water. The piled up floes were angular and there was no trace of any melting. The fractures were fresh and had no similarity to those of the old pack. What we saw was the result of the B-52 hitting the ice.

South of the crash area one could see the "black spot." This consisted of a 1-3 cm (o.5-1.5 inches) thick crust of snow that had been melted, and in a few spots the sea ice itself had melted. Under this crust, the snow was not deformed and there was no sign of any melting. Measurements showed that the crust was strongly contaminated, whereas the underlying snow was clean.

On the basis of these observations and the knowledge gained previously by this author, one obtains the following reconstruction of the events: When the airplane crashed, the ice was crushed and for a short time a lane had been formed filled with floes and bits of ice. One-fifth or one-third of this lane may have been open water. It is difficult to obtain an accurate estimate of the size of the lane since all the irregularities and floes had been covered by drift snow after the time of the accident, but a diameter of about 50 meters (approximately 165 feet) seems likely. It was evident that parts of the B-52 could have sunk to the bottom through this lane.

The "black spot" showed where the burning fuel had streamed from the airplane when it hit the ice. The heat from the fire had no doubt been considerable, but it is also well known that heat does not penetrate deeply into the snow. Within this area no traces were found of large pieces of debris hammered or melted down through the ice, and with an ice depth of 70 cm (27 inches) small objects could not have penetrated the ice either way.

A number of corings in the crushed ice area showed a layer of impurities large enough to be detected with the naked eye. Several of them looked like drops of oil. The measurements showed that this horizon fairly close to the underside of the ice was strongly contaminated. The layer of impurities corresponded to the underside of the ice at the moment of the crash. The impurities stemmed from the accident and had been swimming in the water immediately under the ice cover and were thereafter incorporated into the ice as it grew downwards. The records show that the ice grew at a rate of approximately ½ cm (0.2 inches) per day in the beginning of February.

A more detailed coring program with the collection of samples of the sea ice in the area of the accident was carried out by Dr G. Frankenstein.

CONDITIONS DURING ICE BREAK-UP

The Danish Scientific Group discussed the probable ice situation in the spring. It was obvious that the "black spot" would melt relatively quickly because of the effect of the sun on the dark colored snow and because the crust would melt more rapidly than normal snow anyway. A relatively large pool of meltwater would therefore be formed on the ice, and it was expected that an early formation of cracks and lanes in the ice would follow due to the compression of the snow caused by vehicles used during the clean-up operations. The biologists foresaw that these cracks and holes could attract seabirds, particularly the little auk.

The group also discussed what could be expected to happen to the drift ice once the ice had broken up. The possibility that the ice would go beyond the Thule district could be excluded, since it would melt before it had drifted that far. On the other hand, it was impossible to foresee with any certainty the direction of the ice drift, or whether some floes would drift ashore with their possible contents of contaminated debris. Furthermore, it could not be excluded that some material capable of floating might be carried ashore with the current once the ice had melted. Since the current generally flows northward, it seemed most likely that such objects would be washed up at Saunders Island or Steenby Land. However, since material from the garbage dump at Thule Air Base can float as far as to the head of Inglefield Bredning, the group recommended that a search be made in the summer of the coasts in the vicinity of the crash site.

It was generally agreed that any debris left on or in the ice after the clean-up operations should not be allowed to drift too far. So it was suggested that some dark material be spread over the ice to further the melting. In this way a hole could be melted in the ice and any debris left from the accident would sink before the ice broke up. Experiments with carbonized sand were later made by the Americans at the end of May.

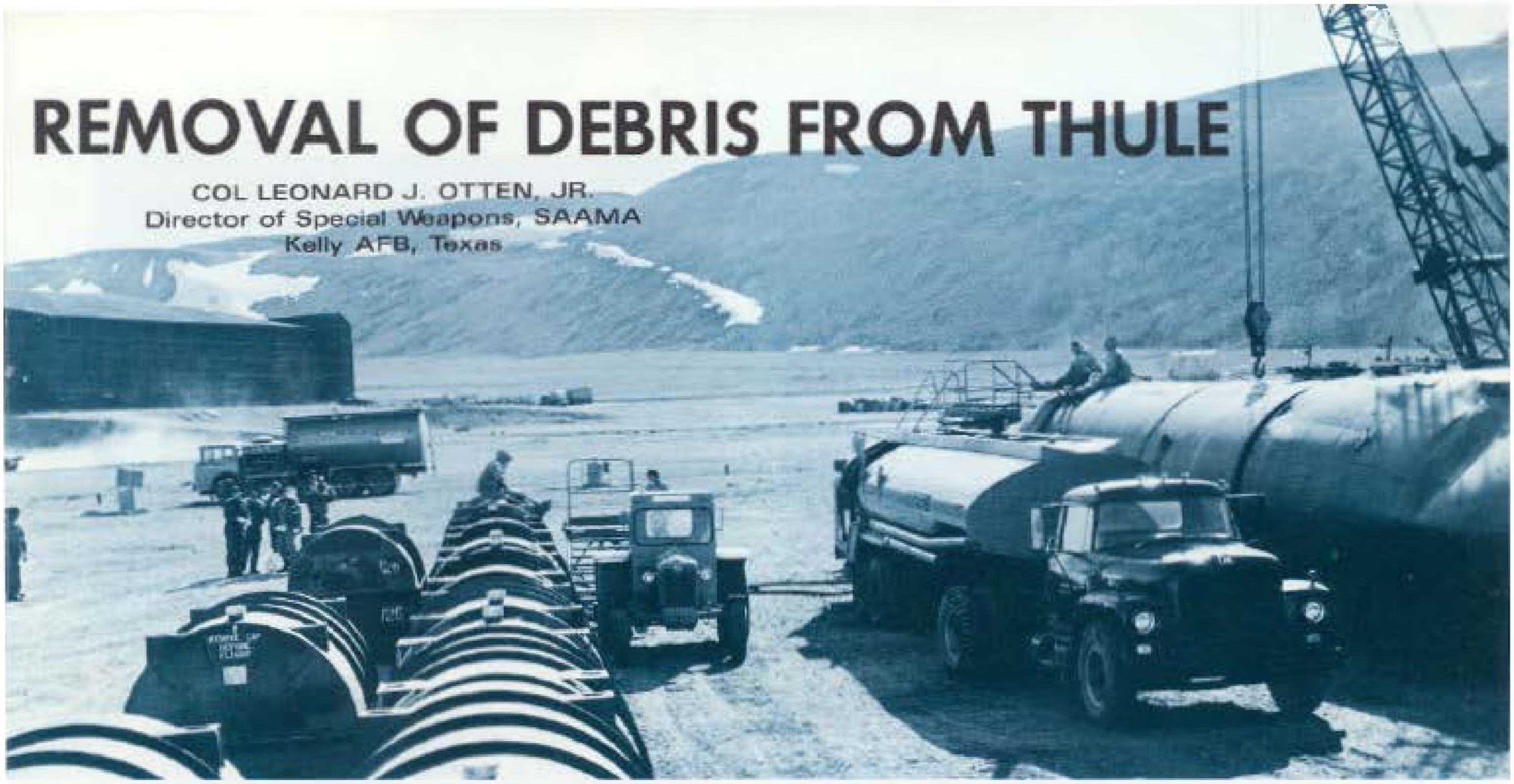
On 29 May, I was again in the Thule area and had the opportunity to follow these experiments. From a helicopter, it could be seen that the carbonized sand had had some effect, but since snow had fallen and covered the sand after it had been sprayed on the ice, the total effect was not too impressive. Time did not allow me to follow the experiments any further.

As has been mentioned in other articles in this magazine, it appeared that most of the contamination was contained in the "black area" and so it was decided to remove this localized contaminated layer of snow.

Without going further into the physical properties of snow and ice, it is clear that the fact that the accident occured on snow-covered sea ice limited the extent of the contamination. There was no contamination of the sea ice in general, and the sea ice from the site of the accident did not go far before it melted away.

REMOVAL OF DEBRIS FROM THULE

COL LEONARD J. OTTEN, JR.
Director of Special Weapons, SAAMA
Kelly AFB, Texas



WITH the completion of on-site evaluation and recovery operations by the Strategic Air Command (SAC), effort was directed toward the problem of dealing with the contaminated waste. During recovery operations, 217 various sized containers of aircraft residue and sixty-seven 25,000-gallon tanks of contaminated snow and ice from the site were collected. In addition, there were four 25,000-gallon containers filled with such items as tires, clothing, tools, plywood, and parachutes.

Transportation requirements for a removal operation of this size created a problem of great magnitude. It was decided to turn the job over to the Air Force Logistics Command (AFLC). Within the command the task was assigned to the Directorate of Special Weapons located at the San Antonio Air Materiel Area (hereafter referred to as SAAMA), Kelly AFB, Texas. Lt Col Vernon E. Carkin, Chief of the Production Management and Technical Services Division, served as Project Officer.

To gather all necessary information, a meeting was held at SAC Headquarters on 8 April with personnel who had recently returned from Thule Air Base following recovery operations. The main questions concerned the amount of waste requiring disposal and its degree of contamination. These questions were directed to the civil engineers and health physicists.

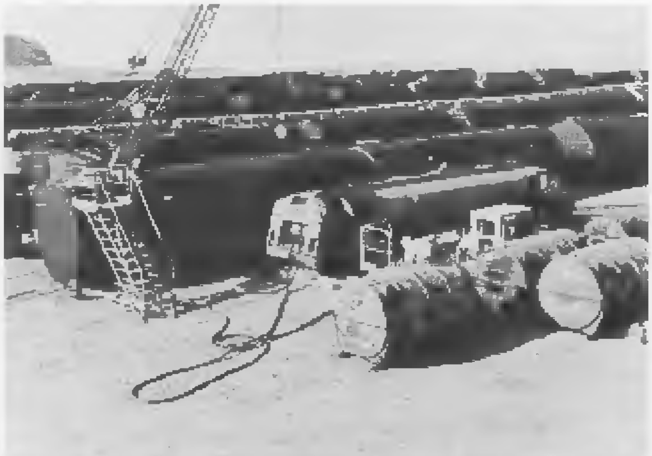
The SAC Civil Engineers estimated that the 67 petroleum, oil and lubricant (POL) tanks were 85% full, with approximately 4,500 gallons of melted snow and ice in each tank. They recommended a filtration process be used to decontaminate the liquids. This would allow the effluent to be discharged into the bay and would eliminate the necessity of transporting the liquids to the United States for disposal. However, the health physicists did not fully agree with this concept due to the high degree of purification required to meet international drinking water standards.

Returning to SAAMA, another meeting was called with personnel from the Atomic Energy Commission, Aerospace Defense Command, and AFLC, who had been at the site. Many ideas and suggestions concerning the handling, storage, and transportation of the radioactive materials resulted from the conference. To insure thorough evaluation and consideration of each suggested plan, a formal staff study was prepared. Many aspects including international opinion, feasibility, climatic and geographic conditions were considered in the study.

Three alternatives were proposed. A brief summary of the plans follows:

One plan was to ship all of the 25,000-gallon tanks and smaller containers, filled with contaminated waste, to the United States for disposal. However, the disadvantages of this plan were far greater than the advantages, with such problems as the requirement for extensive cradling supports from the tank farm to the ship, and also aboard ship. Another hazard was the tilted entry of partially filled tanks into the ship. These procedures could prove to be extremely dangerous.

The second plan provided for handling the radioactive waste by filtration and dilution. The frozen waste was to be melted in the POL tanks. The "clear" liquid between the scum and sludge layers would be pumped through a five-micron filter, followed by three one-micron filters placed parallel and leading to a holding tank. Again, the disadvantages proved too great. The



TANK FARM. Pump-transfer crews prepared to pump melted snow water from the large 25,000-gallon tank to small containers to facilitate shipping the residue to the U.S.

Decontamination personnel unloaded forklift inside designated bunker.

problem was that an adequate filtration system, with necessary operating procedures, had not yet been designed, fabricated, and service tested.

The third plan provided for transfer of radioactive waste into smaller transportable tanks for return to the United States for disposal. Radioactive residue in the POL tanks would be melted and the liquid pumped into smaller tanks made from modified engine containers of 1,800-gallon capacity which were excess to the Air Force needs. The tanks would then be transported from the shoreline storage area to the ship docking area for loading aboard cargo ships. The tanks would be shipped to the United States and transferred to railroad cars for shipment to Atomic Energy Commission designated disposal areas. Empty POL tanks, which originally held the material, would be sent to designated disposal areas as well.

This alternate was approved by the Air Force Logistics Command, Aerospace Defense Command, the USAF Directorate of Nuclear Safety, HQ USAF, Department of Defense, Department of Transportation, Department of State, and the Atomic Energy Commission. After this process, the plan was coordinated with and approved by the Danish Government.

An adequate number of the smaller, modified tanks were available at SAAMA, as well as F-6 aviation gas refueling units which were used as on-site portable pumping equipment. Prior to approval for use, the modified cans were subjected to a severe testing program for leaks, stability, and durability.

To determine the conditions at the site, what equipment was available, and what problems would be encountered during the actual removal and disposal operation, a team of highly specialized personnel visited Thule Air Base.

Upon the team's return from Thule, the SAAMA Military Personnel Office selected the personnel who would make up the on-site task group.

On the morning of 25 June, the hand-picked on-site team assembled at the Directorate of Special Weapons conference room to learn of their assignment. The team consisted of 24 personnel—one officer, 18 airmen, two civilians from SAAMA, two airmen from the Tactical Air Command, and one from SAC.

Faint murmurs ran through the group. What is this all about? What is Project Crested Ice? How long will this thing last? And, of course, why me?

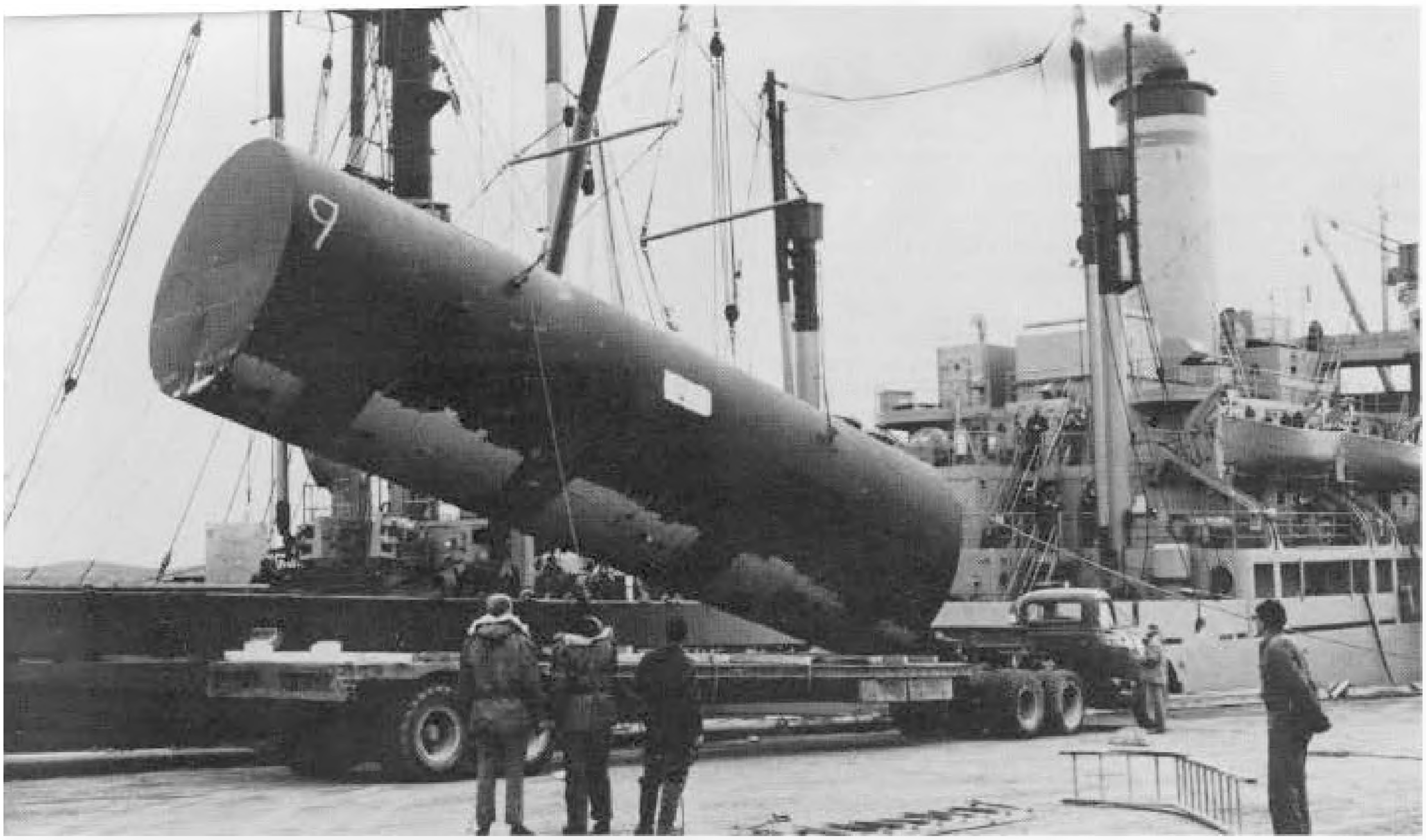
These and all other questions were answered during a comprehensive briefing concerning the mission, constraints and time schedules, international interests and relationships. Individual crew assignments were made in the major areas of effort: melting, pump transfer, radiological monitoring, packaging and transportation, and finally, administrative and control functions.

Training the task group began on the 26th of June at Kelly Air Force Base. The training was unusual; the circumstances were unusual. Some learned to heat ice filled tanks rather than aircraft engines, others to pump-transfer radioactively contaminated liquids without spillage instead of pumping aviation fuels, while still others learned to palletize and label drums of radioactively contaminated aircraft debris rather than oil drums.

The personnel who were given secondary or augmenting assignments were cross-trained. Those not currently qualified to operate related equipment received intensive training and were licensed by Kelly authorities. On 11 July, the team left Kelly Air Force Base on a C-118 which became affectionately known as "Thule Commuter's Special."

Upon arrival at Thule the following day, the group was briefed by the SAAMA Advance Liaison Officer. The briefing included a tour of the local area.

On 16 July the USNS TOWLE of the Military Sea Transport Service, docked at Thule's DeLong Pier and immediately began unloading the Crested Ice equip-



LOADING OPERATIONS. Empty POL tanks are placed aboard the USNS TOWLE for shipment to Charleston, South Carolina.

Fuel tank being lifted onto flatbed by crane.

ment, including 232 modified engine containers and two F-6 refueling units.

To protect against spillage, additional equipment was manufactured at Thule Air Base. Sheet metal pans were made to place under the F-6 units and collars were fabricated to encircle the R-4360 filler caps and POL tanks to soak up contaminated liquid from suction or discharge nozzles.

Other innovations were made such as the adaption of a POL system filter unit to fit around the suction nozzle to screen out debris from the POL tanks.

All preparatory efforts of the pump-transfer operations were completed by 22 July.

The igloo area operations began 17 July with the manufacture of barrier bags to completely contain and seal the drums and cans of residue for shipment.

During the operation, it was discovered that one of the modified cans and one POL tank had leakage due to punctures. However, it was determined that the liquid was not "hot" and the containers were repaired with an epoxy compound.

Additional safety briefings were held by the On-Site Health Physicist, Capt William Moyer. He reviewed the hazards and demonstrated the use of available protective clothing and gear.

Full pump-transfer operations began 22 July, with two crews, each with a radiological monitor, operating 10 hours a day. Competition immediately sprang up between the crews to see which could pump the greater amount each day.

Thanks in part to the prevalence of good weather, 49 of the 67 POL tanks of contaminated liquid waste were emptied and two hundred and thirty-one R-4360 containers filled by 29 July. One-hundred gallons were left in each POL tank as a dampener to lessen the danger of sparking effects of debris. The 232d container was sent to the Danish Construction Corporation, a Thule Air Base contractor, to serve as a model for modification and test of the eighty R-4360 cans arriving on the USNS TOWLE's second trip to Thule.

Since the USNS TOWLE was not due to return to Thule until 20 August, the members of the task group returned to their home stations. The Thule operations were secured and left in the custody of two task group members. Their tasks included housekeeping, maintaining daily surveillance over filled containers, and to note any pressure build-up.

The on-site team reassembled and returned to Thule Air Base on 15 August. Upon arrival, additional modification of the previously filled cans was necessary.

A .0625-inch hole was drilled in the filler caps with a rubber surge chamber inserted to eliminate any possible air/gas pressure build-up inside containers as they were transported from a 30-40 degree environment to the possible 90-100 degree temperature of the Southern United States.

When the USNS TOWLE arrived on 21 August, its cargo of an additional 80 unmodified R-4360 cans was taken to Hangar 1 for modification. The last container was completed on 31 August.

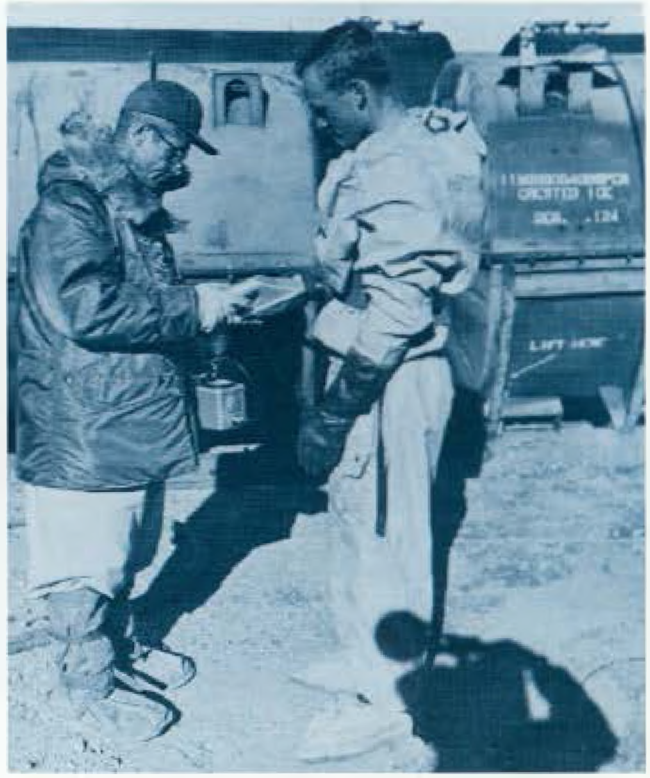
The loading of the USNS TOWLE began with eight POL tanks, 50 pallets of 192 drums and 268 filled R-4360 cans during the period 26 August to 1 September.

Departing Thule's DeLong Pier on 2 September, the USNS TOWLE headed for the Army Pier at Charleston, South Carolina, with a due date of 11 September.

When the USNS TOWLE arrived at the South Carolina pier, railroad cars were waiting to take the contaminated debris to its final resting place. Sixty-six cars were needed to carry the load which was moved at a speed of not more than 30 miles per hour.

The second ship, the USNS MARINE FIDDLER, arrived at Thule on 3 September and began loading

FILL 'ER UP. Airman at Thule fill engine container with melted snow water pumped from the larger POL tank.



FINAL CHECK. A radiological monitor checks for contamination of alpha particles on the clothing of a pump transfer operator by using PAC-1S scintillator detector.

Crested Ice retrograde cargo. It departed on 17 September with forty-seven R-4360 cans and five 25,000-gallon POL tanks, 67 empty 25,000-gallon POL tanks and eleven 3,000- to 10,000-gallon POL tanks of residue and the two F-6 refueling units. The MARINE FIDDLER arrived in Charleston on 28 September with its cargo. It was necessary to use 81 railcars to transport the containers. To keep the material from sloshing to any great degree and because of the close clearances, the train moved no faster than 20 miles per hour to its destination.

With Thule Air Base secured, the task group departed on 6 September, after assuring that the former tank farm area was left clear and monitored to a zero contamination level. The AFLC/SAAMA project close-out responsibilities were completed.

SUMMARY

We would be remiss if we did not acknowledge the contributions made by the Danish Nationals assigned to Thule Air Base. They were, without exception, professionals in their jobs and their cooperative and constructive attitudes were outstanding. The SAAMA team will long remember these fine people, both for their proficiency and for the warm personal relationships that developed.

Our only regret is that we could not have met with the Danes under happier circumstances.

NORTH STAR BAY OCEANOGRAPHY

LT COL MARSHALL E. NEAL
LT COL WESTON A. ROE
Directorate of Nuclear Safety

Photo used by permission of General Dynamics

IN separate articles, our Danish colleagues have reported on the extensive radioactivity measurements in the biosphere which they conducted at North Star Bay and in its surroundings. This article adds to that picture the details of two supporting American programs. One of these provided measurements of North Star Bay currents, the other surveyed conditions on the ocean floor.

The ocean current measurement program was conceived in the early days of the operation, before it was known what procedures would be required to preclude any danger to plant or animal life. The currents were needed in order to estimate how the ice might drift, following the spring breakup. Although it was eventually decided that the ice at the crash site should be cleaned up, so that the original purpose of the current measurements disappeared, the program did present an interesting operational problem at the time. To measure the currents it was necessary to drill holes in the ice through which current meters could be lowered. At the same time it was possible to lower a camera with lights to the ocean floor in order to obtain the first data on the general nature of the bottom.

Later, when the Bay cleared of ice in the summer, Air Force, Navy, and their contractor personnel joined with the Danes in an ecological survey of the Bay area. The U.S. contribution to this effort was to survey the bay bottom directly beneath the crash site. This part of the joint survey, besides contributing to the general scientific knowledge of environmental conditions, was designed to verify that any contaminated aircraft debris which might have broken through the ice was stably situated on the bottom. It was carried out with the use of a small research submersible, the STAR III (Submarine Test and Research Vehicle).*

These activities, and their results, are described in the following paragraphs:

HYDROGRAPHIC SURVEY OPERATIONS

A team of four personnel from the U.S. Naval Oceanographic Office (NAVOCEANO) arrived at Thule Air Base on 25 March 1968 to measure the flow of currents in the Bay.** Figure 1 shows the general area of their operation.

North Star Bay has two main channels. The deepest water is in a channel from Kap Atholl on the southwestern end to Wolstenholme Fjord on the northeast. Another relatively deep channel extends westward from Wolstenholme Fjord between Saunder Island and the mainland. The channel between Saunder and Wolstenholme Islands is shoal water. Maximum water depth in the general area of the crash site is approximately 135 fathoms (247 meters).

The geography of the area indicates four possible paths through which water might flow out of the area of the crash site:

• Between the northern tip of Saunder Island and Kap Abernathy on the mainland;

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*The STAR III is a small two-man oceanographic research submersible equipped with lights and cameras. It was leased by the Navy from General Dynamics/Electric Boat Division.

**The discussion of NAVOCEANO operations is the contribution of Mr. L. J. Fisher and Dr. L. K. Breslau.

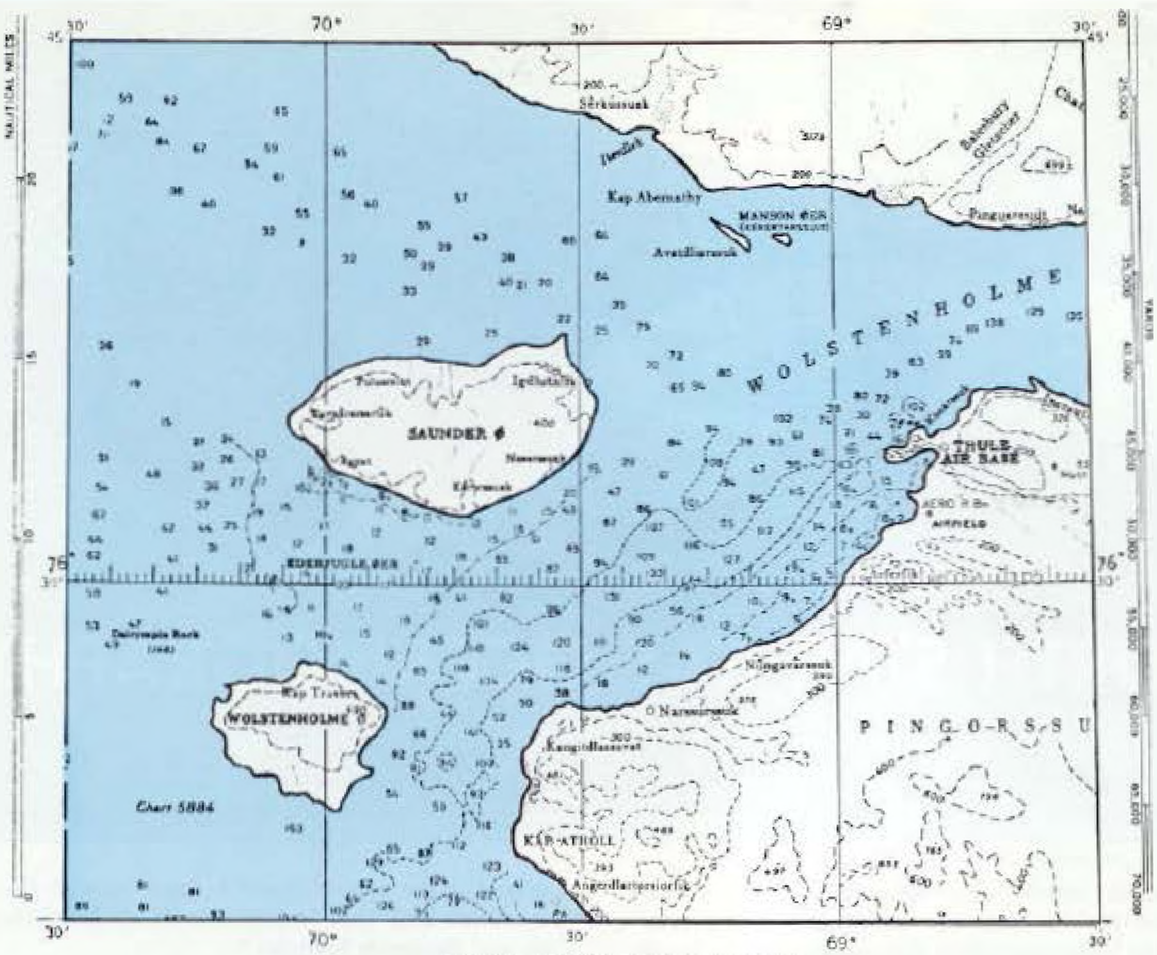


Figure 1. General Operational Locale.

- Between Saunder and Wolstenholme Islands;
- Between Wolstenholme Island and Kap Atholl on the mainland;
- Into Wolstenholme Fjord.

Midchannel current measurements were planned in each of the four passages to determine the direction and speed of the current through these passages. In addition, current measurements were to be made at each of three stations extending across the general area of the crash site on a line from Nasarssuak on Saunder Island to Nungavarssuk on the mainland. The planned current measurement sites (Figure 2) were precisely located by a USAF geodetic survey team before the NAVOCEANO field operations began.

Original plans specified 24-hour surface and bottom current measurement at each of the seven sites. A string of five current meters was to be installed at Site 1 at the beginning of the operation for continual data recording until retrieval of the meters at the completion of the operation. Bottom photographs also were to be taken at Sites 1 and 2 upon completion of the current measurements. The current meters and camera were to be lowered and raised with a winch mounted in a specially constructed mobile laboratory. Since rapid deterioration of the ice prevented moving the heavy mobile laboratory and camera lowering equipment to Sites 3, 4, 5, 6, and 7, operations there were conducted lowering and raising the current meters by hand.

The current data were obtained with two types of meters—the Hydroproducts Model 501B and the Geodyne Model A-101. The Hydroproducts meter is a system with an integral recorder capable of unattended recording of current speed, direction, and temperature for periods up to 30 days. The record is a permanent analog plot that can be analyzed immediately after recovery of the meter. These meters were used to obtain a 24-hour current record at each site. The records were analyzed as soon as possible to provide the on-site Strategic Air Command (SAC) Disaster Control Team with immediate information on the surface currents in the vicinity of the crash site. The Geodyne meter is a system capable of recording up to 200 days of current speed and direction data. The data are recorded as a digital coded dot matrix on photographic film. These meters were used to obtain a 7-day record from five different depths at Site 1. These data were not processed until the field team returned to NAVOCEANO where the necessary processing facilities were available.

The current meters were lowered through 2-foot diameter holes drilled in the ice with the ice auger. The thickness of the ice in the area ranged from a minimum of 20 inches to a maximum of 48 inches. The data collected indicate that the currents in the area are pro-

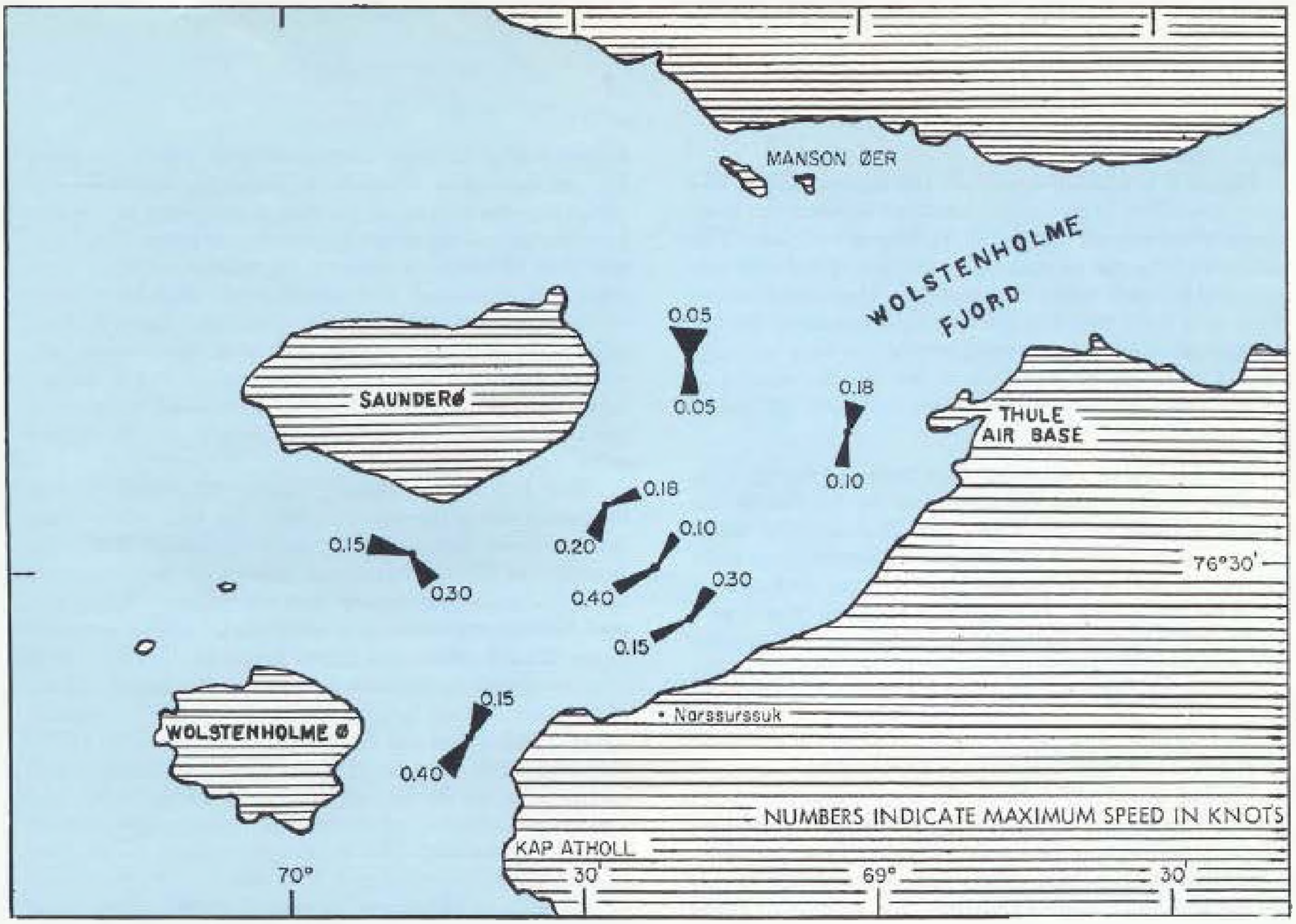
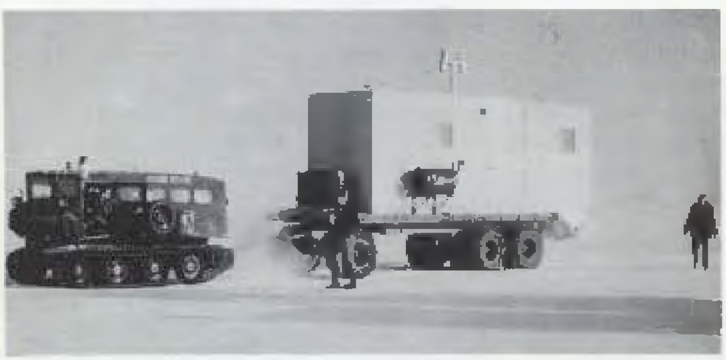


Figure 2. Summary of current data.



Mobile oceanographic laboratory.

Measuring the currents of North Star Bay.

Hydroproducts Current Meter

Geodyne Current Meter.

dominately tidal.

Figure 2 is a summary of all the current data.† The cones extending from the site locations indicate the most frequently observed current directions at each site. The numerals indicate the maximum current speed in knots recorded for each range of directions. The final analysis of the data indicated that the currents measured during this operation were not strong enough to have any significant effect on the breakup of the ice. Movement of the ice was thus dependent upon the wind direction and speed.

The Air Force requested that bottom photographs be taken to determine the nature of the bottom in the general vicinity of the crash site. Photographs taken at Site 1 at a depth of 240 meters indicated very little marine life and a soft bottom typical of an area of fine sediment deposition. Photographs taken at Site 2 at a depth of 135 meters indicated an abundance of marine life and a rocky bottom typical of the sea bottom of the coastal waters and of an area scoured by bottom currents.

RESEARCH SUBMERSIBLE OPERATION

During August 1968, three Air Force observers from the Directorate of Nuclear Safety and three submarine pilots from General Dynamics/Electric Boat Division, performed deep submergence operations in STAR III during the final phase of Crested Ice response. These were the northernmost research submersible diving operations ever undertaken by the United States.

The U.S. Air Force received excellent support for the ocean bottom survey from the U.S. Navy, the U.S. Coast Guard, numerous contractors and subcontractors, and the Danish Construction Corporation. The Navy Supervisor of Salvage, contracted with Ocean Systems, Inc., of Arlington, Virginia, to place the Air Force observers on the bottom of the Bay at the point of impact. Various tasks of the effort were subcontracted. The Electric Boat Division of General Dynamics, Groton, Connecticut provided the submarine, the necessary submarine support equipment, photographic and video tape recording equipment, and boat operations personnel. John E. Chance and Associates of Baton Rouge, Louisiana, provided the surface navigation support to place submarine operations accurately in the survey area.

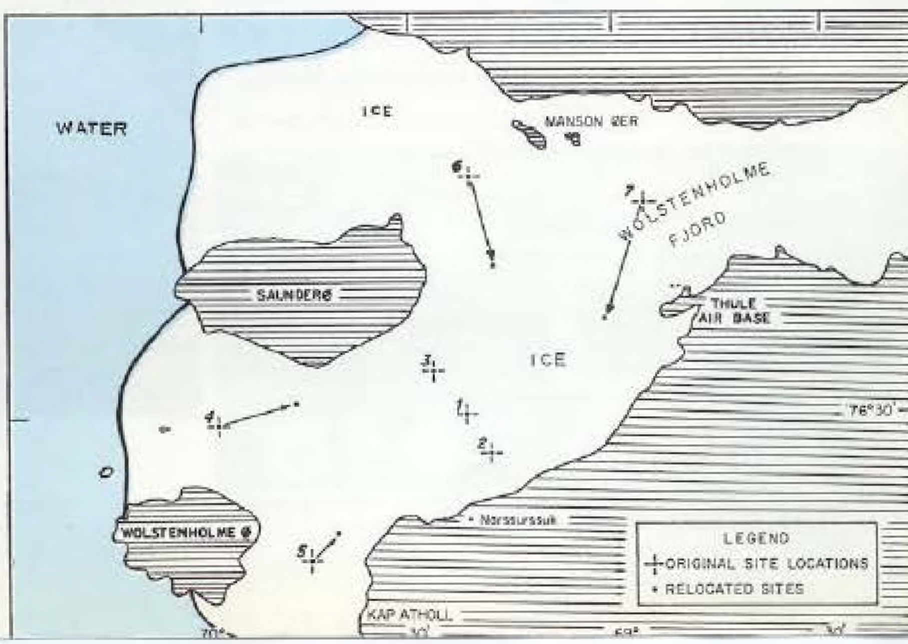
The U.S. Coast Guard Cutter WESTWIND was operating out of the port at Thule Air Base when plans for the ocean bottom survey were approved. The commander at Thule Air Base, who was the on-scene commander for this survey, and his Military Sea Transport Service representative were successful in securing Coast Guard boats and crews from the WESTWIND who rendered invaluable assistance. An arctic survey craft about 50 feet long performed the tow operations to get STAR III to and from the survey area. An LCVP (landing craft, vehicle, and personnel) positioned reference lines on the bottom and buoys in the water and transferred essential materials and people during surface operations. The submarine pilots, assisted by Coast Guard divers, braved 37° water in either wet-suits or dry-suits, to disconnect or reconnect the towbar each time the submarine was towed to or from the survey site.

Communications, weather, helicopter crash/rescue operations, heavy equipment and its operation, space and facilities, protective clothing for arctic operations, administrative and other logistic support for the survey were provided regularly and promptly throughout the effort. The Thule Photography Laboratory worked throughout the diving operations to develop and print the still photographs taken of the Bay bottom.

Most diving operations during Crested Ice were con-

† When submerged operations began in August, tidal condition approximated those measured during this effort. Tides were a little stronger on one occasion.

Drilling a hole in the ice.



Site Locations.

ducted to depths of 100 fathoms (600 feet) or more. The marine life on the ocean bottom in North Star Bay consisted of shrimp, various types of starfish, bivalves, shellfish, and barnacles. Jellyfish and shrimp were iridescent as they scurried before the quartziodide lamps rigged on STAR III.

When the crew had sealed the diving sphere, and were cleared for operations, the STAR III began to descend slowly, inching the conning tower below the surface as negative buoyancy built up. As soon as the boat was below the surface, communications switched from radio to underwater telephone. Boat lights were required for visibility below about 100 feet. The water temperature also decreased as STAR III descended but was measured at a constant 32°F at and below about 200 feet throughout more than 2 weeks of diving. The temperature inside the sealed sphere was comfortable, although the steel sphere was cold to touch and condensed moisture profusely. The crew described the sphere, heated by the motors and equipment, as "the warmest spot in Greenland." The oxygen supply and life support system required periodic checks for crew safety but worked quite satisfactorily. The checks consisted of measuring the percentage of oxygen and detecting any carbon dioxide in the diving sphere. The life support system provided a continuous flow of oxygen from a regulator on a pressurized supply bottle. Carbon dioxide was filtered out by recirculation through a chemical pack; spare filters were carried inside the boat.

Water conditions and light intensity permitted the observers to see clearly out to 20 feet—sometimes beyond 25 feet. The best visibility for the purposes of this operation was achieved by moving the boat forward slowly 6 to 18 inches off the bottom. Most of the survey area revealed no evidence of the crash nor of years of human activity on the waves and ice above. There was a wide variety of debris in some places on the bottom: juice cans, milk cartons, candy bar wrappers, and wreckage. One item observed was an "A" frame. It was found 90 feet from the datum point on the first dive. This "A" frame was used during the crash recovery and cleanup effort and left on the ice. When the ice melted, it sank to the ocean floor and thus became a marker of sorts, helping to verify the datum point. Another indication of the accuracy of the datum point was the presence of a crowbar standing in the silt. Early in the accident investigation effort, the crowbar had been dropped through a hole in the broken ice. There were areas of concentrated wreckage, but usually the concentration was light, the pieces widely scattered, and small; often only a few square inches of surface area or a long slender piece of debris. There were small pieces of crumpled sheet metal, stringers, dynamotors, and pieces of wiring, tubing, and tires. As expected, the aircraft debris was stable and well fixed. Over much of the survey area, no wreckage existed.

The abundance of coelenterate life on the sea floor contrasted sharply with the barren surroundings near Thule. Starfish, brightly colored mollusks, and marine animal-flowers called anthozoans were plentiful. In some ways, the ocean bottom seemed an environment less hostile to man than the surface, until the extent of support needed for human survival was recalled.

Four and three-quarter hours was the maximum submerged time for underwater arctic operations with the STAR III submersible. This allowed an average of 3 hours of productive survey time per dive. Except for switching off and stowing any equipment not required for surfacing the boat, the ascent sequence closely resembled descent.

A relief pilot rode the STAR III as it was towed back to port, which gave the dive crew a chance to relax. The trip between the datum point and shore took about 2½ hours. On one occasion the fog started to move in past Kap Atholl and Saunder Island. Tension mounted for the team until the arctic cruiser had towed STAR III beyond the bigger icebergs. Some difficulty plagued every dive. In spite of some foul weather, limits on time, camera failures, and icebergs, STAR III and its support team performed the required submerged boat operations very well. The surface navigation system repeatedly placed the team positively on their reference point during 11 diving operations.

The successful underwater survey helped to confirm previous joint scientific findings that there was no radiological hazard from the limited aircraft debris on the ocean floor below the point of the crash.

Macoma Calcarea shells and Ophiuroids on the bottom of North Star Bay.

Arctic cruiser with STAR III in tow.

William A. DeCourt of General Dynamics enters STAR III to begin a dive.

EPILOGUE

From the Danish Point of View:

THE Thule District in the northwestern part of Greenland, is one of the most inhospitable places man has ever inhabited, and except for the American air base near Thule, hundreds of miles separate the isolated Thule Greenlander hunters from other permanent settlements. Yet the Thule District is part of Denmark, and it was evident that when suddenly faced with an unprecedented and possibly dangerous situation, the people there would first turn to Danish authorities for guidance and protection.

No danger to man or animal and plant life was created by the Thule accident—that is now a well established fact. Within a week after the accident, this was the preliminary view of American and Danish scientists applying usual scientific methods and working side by side, although quite independently. Through swift action, and with the American and the Danish press as ever present witnesses, a situation, which obviously involved many problems, was brought under control, and unnecessary alarm avoided.

Although no one in Denmark had foreseen exactly this type of emergency, it turned out that resources and, most important, willingness to put them into action were in fact available. The record, which has been given here, is a tribute to the men of good will, Americans and Danes, who without regard to the rigours and discomforts gave their wholehearted support towards the solution of the problems at hand.

HANS HENRIK KOCH
Permanent Under-Secretary of State
Chairman, Executive Committee
Danish Atomic Energy Commission

EPILOGUE

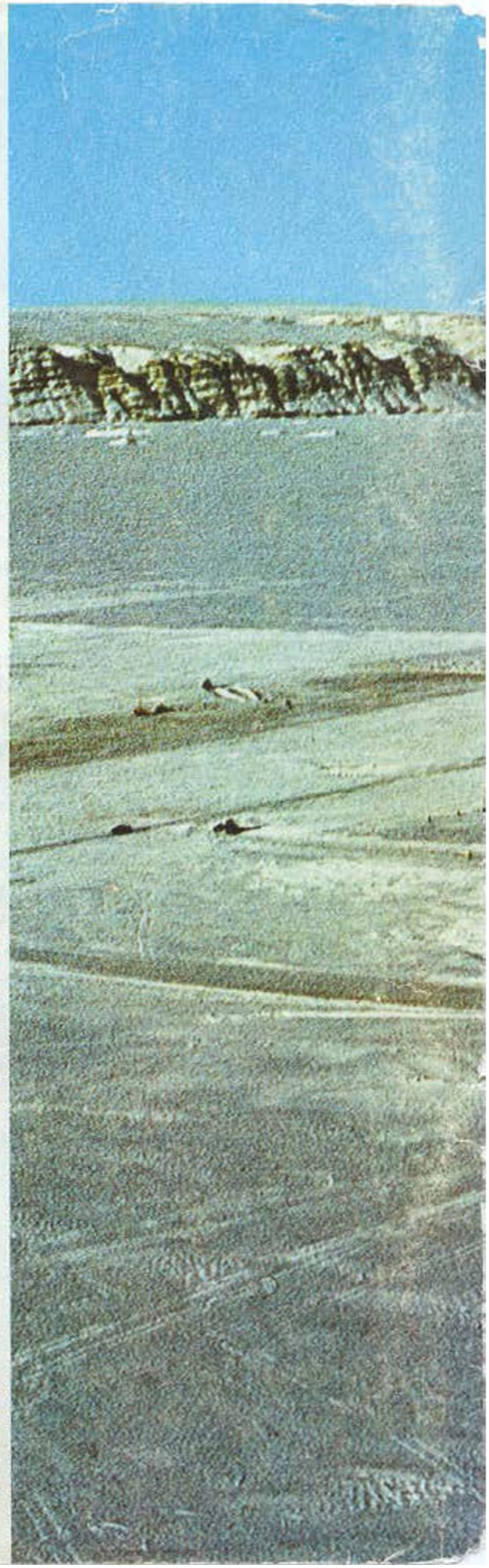
From the American Point of View:

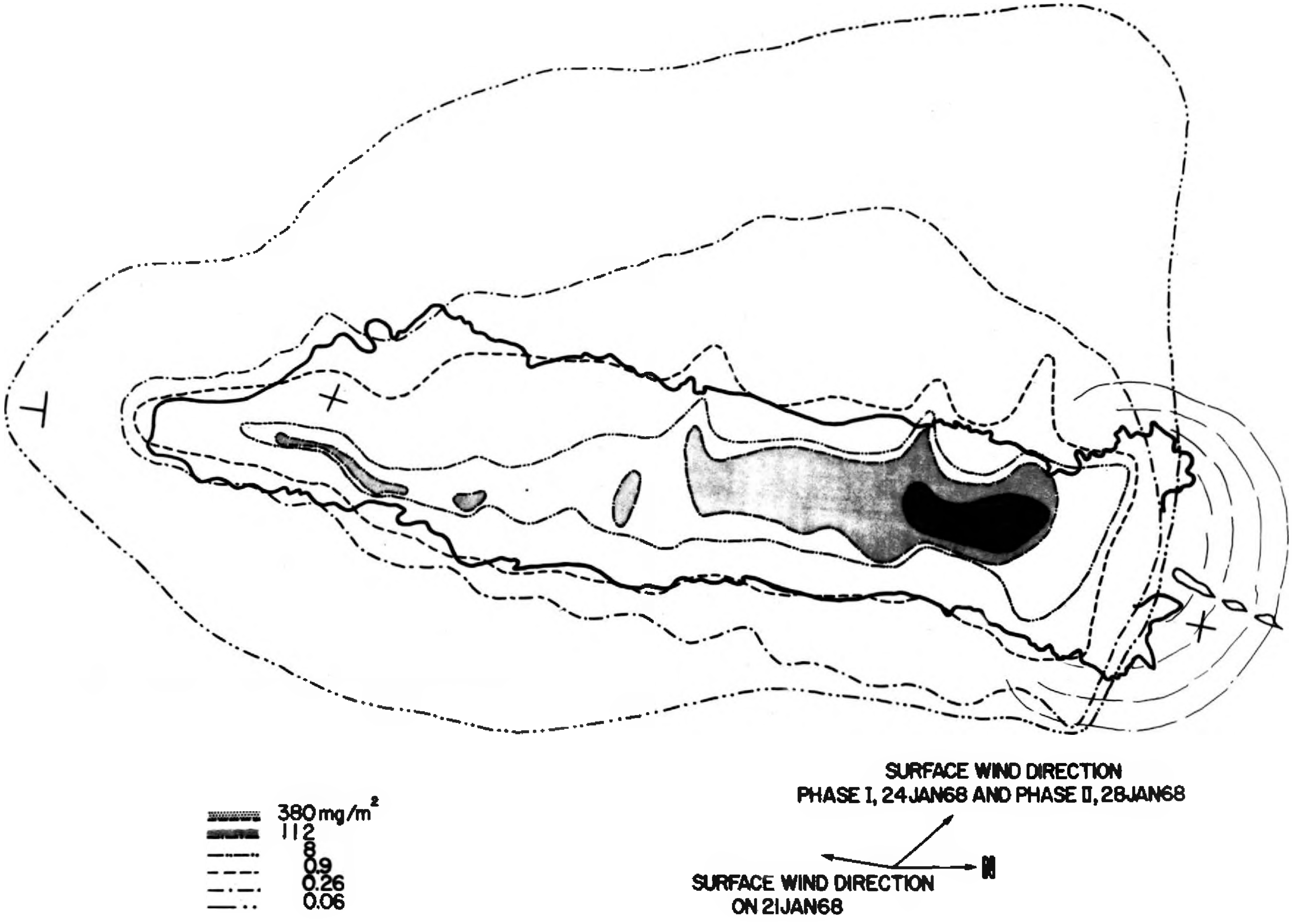
THE Thule accident was a shock to us all. We were saddened by the death of one of the crew and concerned with the harsh realities which would face our accident control team's efforts. The threat that the unforgiving arctic climate could exact a further toll made the outlook ominous. The situation seemed grim.

And yet, from such a harsh beginning, the days that followed saw a monumental performance by the team at Thule charged with surveying the accident scene and taking remedial housekeeping actions. Under the leadership of General Hunziker, Air Force personnel, with the assistance of their colleagues from other services and of Danish and American scientists, the cleanup moved forward rapidly in the most extreme climatic conditions. Within a few months this team brought Project Crested Ice to a successful conclusion without further loss of life. By September the contaminated debris and snow which was collected from the crash scene had all been removed from Greenland. Furthermore, an extensive ecological survey, led by Danish scientists, had reconfirmed that no hazard remained for animal or plant life.

This conclusion was due to the skill and devotion of all those involved. It attested to the dedication of each participant. We owe much to all those who participated on the American-Danish team. Once again the record reveals that the combined efforts of men, well-led, can triumph over the greatest adversities.

CARL WALSKE
Assistant to the Secretary of Defense (Atomic Energy)





SURFACE WIND DIRECTION
PHASE I, 24JAN68 AND PHASE II, 28JAN68
380 mg/m²
112
8
0.9
0.26
0.06
N
SURFACE WIND DIRECTION
ON 21JAN68

CIC-9: 68-3489